SECOND REPORT

WELLCOME RESEARCH LABORATORIES

AT THE

GORDON MEMORIAL COLLEGE

KHARTOUM

ANDREW BALFOUR, M.D.

DIRECTOR

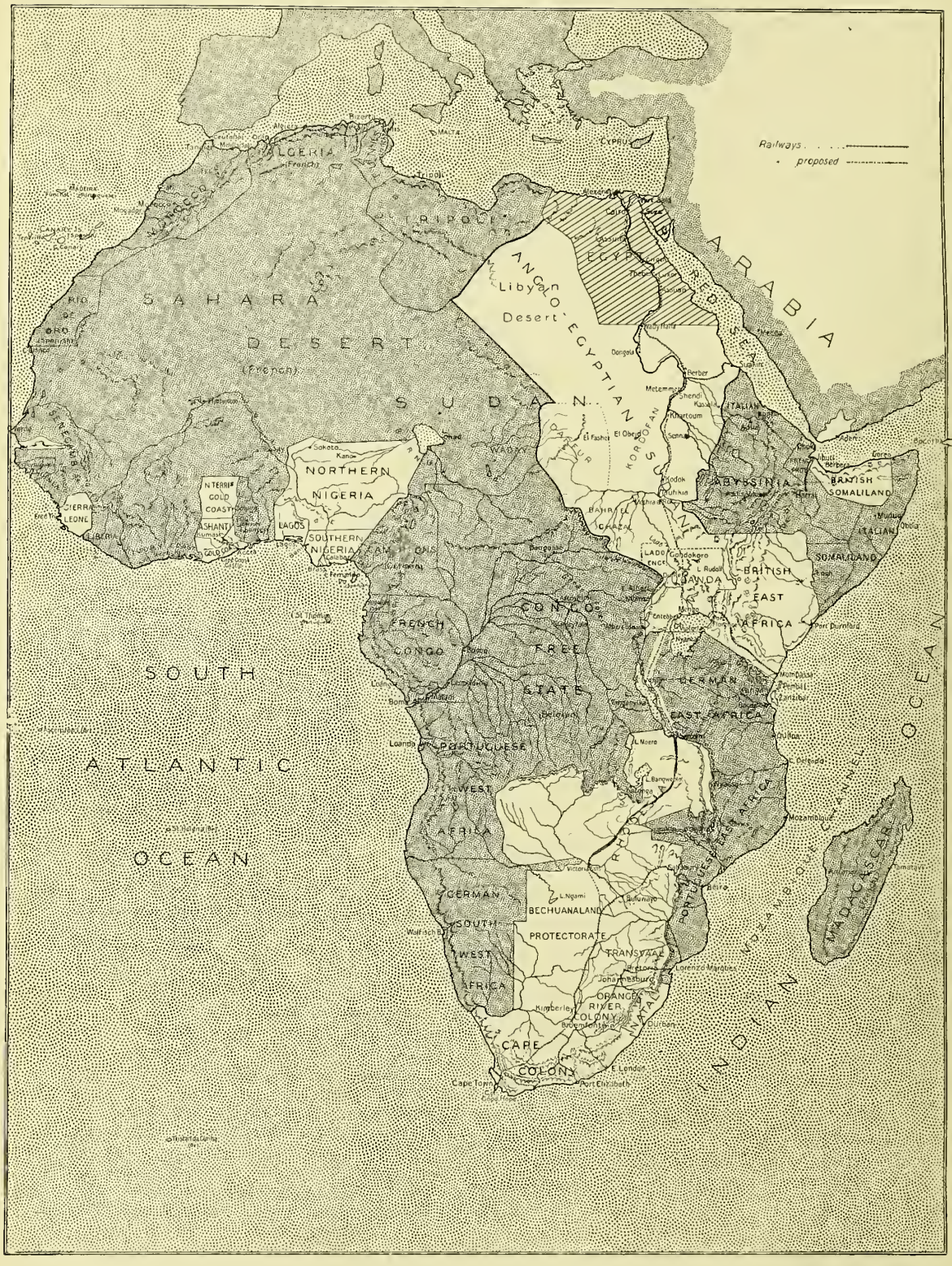

FIG. 1.—MAP OF AFRICA SHOWING BRITISH POSSESSIONS AND THE BOUNDARIES OF THE ANGLO-EGYPTIAN SUDAN

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DIRECTOR

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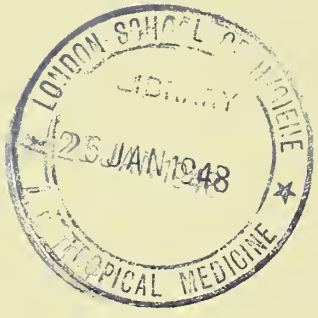
Epidemiological Society, the Incorporated Society of
Medical Officers of Health, and the Association
of Economic Biologists, Medical Officer of
Health, Khartoum, &c.

Department of Education, Sudan Government,
Khartoum
1906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OF THE

WELLCOME RESEARCH LABORATORIES, 1906

Director	ANDREW BALFOUR, M.D., Etc.
Chemist	WILLIAM BEAM, F.I.C., Etc.
Travelling Pathologist and Naturalist for 1905	SHEFFIELD NEAVE, M.R.C.P., Etc.
Economic Entomologist	HAROLD H. KING (Appointed March, 1906)
Assistants	H. R. FRIEDRICHS J. A. GOODSON, A.I.C. (Appointed January, 1906)
Clerk	MAHMOUD EFFENDI KHALIL

Mr. F. V. Theobald, M.A., etc., has again acted as Consulting Entomologist and furnishes a chapter on Culicidæ, Human and Animal Pests and Vegetal Pests.

Mr. E. E. Austen, of the British Museum, has rendered much valuable aid in the identification and classification of Diptera, and contributes an article on the Biting Flies of the Sudan.

CONTENTS

FIG. 2.—DUST STORM sweeping over Khartoum North, and viewed rom Khartoum (*see page* 13)

INTRODUCTION

THE First Report of these laboratories was issued in the autumn of 1904. It gave an account of the work performed during the first year of the institution's existence, that is to say down to the end of January, 1904. Since that period I think one can safely say that the record has been one of steady progress. Such, at least, is the case regarding the work performed. It has greatly increased both in amount and variety but, fortunately, additions to the staff have rendered it possible to cope with the routine duties, while some efforts at research have also been made.

In the First Report I foreshadowed the appointment of a chemist, and suggested that a trained collector and observer with a roving commission in the Sudan, would constitute a valuable addition to our forces and increase our knowledge of Tropical Pathology.

The first post was in due course filled by the selection of Dr. William Beam, whose reputation as a chemist is widely spread, and who is especially well versed in economic chemistry. He commenced his duties on October 2nd, 1904, and there can be no doubt that his appointment has been amply justified. He has been kept constantly busy, and it is gratifying that the chemical portion of this Report bulks so much more largely. A special effort has been made to render the chemical research of as practical a nature as possible, as it is believed this will best meet the needs of a rapidly developing country like the Sudan. I would draw special attention to Dr. Beam's investigations on the river water of the country, and on its grains and salts. Work on gums has also been commenced.

Appointment of a Chemist

Like Egypt, the Sudan depends for its prosperity chiefly on the Nile, or rather, the Niles and their tributaries. Dr. Beam early began special analyses of the waters of the Blue and White Niles, and at the request of H.E. The Governor-General, these investigations were ultimately extended to the waters of other rivers. They are not yet completed, but a good start has been made and some interesting points have already been elucidated. Again, the Sudan must in the future develop along agricultural lines, so that work on the constitution of its cereals is of interest and of considerable importance. At present its gum forests are the Sudan's chief asset and enquiry has shown that very little is really known about gums. Dr. Beam's labours may yet serve to place the trade in this commodity on a sound basis. It will, at any rate, probably demonstrate the excellence of several varieties of Sudanese gum. There has been much general work on water, milk, food-stuffs, mineral deposits and natural products. It was a more difficult matter to fill the other post but, thanks to Mr. Wellcome's munificence and the interest H.E. The Governor-General took in the matter, Dr. Sheffield Neave was appointed under the title of Travelling Pathologist and Naturalist. Although it has been impossible to retain Dr. Neave's services for a second period of six months he has achieved a considerable amount of valuable work, often under very trying circumstances, during the short period at his disposal.* This statement can be amply verified by a perusal of his appended Report. One of the chief reasons which made me urge his appointment was the rapid spread of Sleeping Sickness into the northern parts of Uganda, and the proximity of the Sudan to the Nile Province of that country. This led one to fear that, if *Glossina palpalis* existed on the Upper White Nile in Sudan territory, the disease might spread and play havoc amongst the Baris, Dinkas

Appointment of a Travelling Pathologist and Naturalist

* It is hoped that this division of the work will be continued at a later period.

and other tribes inhabiting that region. True I had not found the fly in these parts, but my observations had been very limited, and a thorough examination was most necessary. That such was the case was speedily proved by the news that Captain Greig of the Royal Society's Commission in Uganda, had been deputed to travel north and examine both banks of the Nile not only in Uganda but in the Sudan. It so happened that Dr. Neave was able to meet him at Gondokoro and co-operate with him. Captain Greig being pressed for time did not extend his observations further than Bor. Dr. Neave made a more lengthy exploration and his results, being negative, coincide with those already published by Dr. Greig. Dr. Neave then marched through a portion of the Bahr-El-Ghazal province finding *G. morsitans* present but no sign of *G. palpalis*.

Dr. Neave's expedition

In addition, Dr. Neave made many blood examinations and discovered new trypanosomes in fish and birds. He also found other blood parasites which are described and figured in his Report; Captain Greig kindly committed to his care a Uganda boy suffering from trypanosomiasis, and Dr. Neave was able to test the effect of a new therapeutic agent, which has also been tried in cases of animal trypanosomiasis in the laboratories.

Several new mosquitoes were taken by Dr. Neave, and he brought back a collection of biting flies, native drugs and other specimens of interest.

His expedition has, therefore, been productive of valuable scientific results, and he has obtained useful information for the Government.

From evidence supplied by Major Bray of the Egyptian Medical Service it is evident that the danger is to be looked for in the direction of the Congo Free State and Bahr-El-Ghazal province, a point to which allusion will be made later. The discovery of *G. Morsitans* by Major Morant in Southern Kordofan is another fact of somewhat ill-omened interest. At the instance of the Sudan Commission on Sleeping Sickness, Major Dansey Browning, of the Egyptian Medical Service has been sent in charge of an Expedition to observe and report in the southern part of the Bahr-El-Ghazal province. These laboratories have supplied the scientific outfit for this work.*

Equipment supplied to the expedition of the Sudan Sleeping Sickness Commission

At the end of 1904, Mr. Newlove terminated his connection with the laboratories, being appointed Sanitary Inspector for Khartoum. His work with the mosquito brigade had specially fitted him for such a post. His place was taken by Mr. H. R. Friedrichs, who came with good credentials from Leith Technical College and elsewhere.

The staff has also been increased by the appointment of a clerk in the person of Mahmoud Eff. Khalil, a late pupil of the College who has completed his training. This has considerably lightened the office and clerical work which was fast becoming a burden and greatly interfered with research.

Appointment of a clerk

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* His Excellency, the Governor General of the Sudan, has directed that a Commission be appointed to investigate the possibility of the extension of "Sleeping Sickness" into Sudan Territory. The Commission to be as follows:—Lieut.-Colonel G. D. Hunter, D.S.O., P.M.O.E.A., Dr. Andrew Balfour, Director of the Wellcome Research Laboratories, Khartoum, A British Medical Officer, Egyptian Army, or Medical Inspector, Sudan Medical Dept., or such members as may be hereafter appointed.

Points to be Investigated.

1. To ascertain the distribution of various species of tsetse flies or other biting flies in the Sudan.
2. To ascertain if the disease at present exists in Sudan territory. If so, to determine the exact areas—and to what extent the distribution of the disease coincides with the presence of the tsetse or other flies in these areas.
3. A systematic investigation of the blood and lymph glands of a population in an infected district.
4. A thorough and complete research into the character of the disease, especially as regards its origin and spread.

In the bacteriological laboratory attention has been chiefly directed to the question of trypanosomiasis in equines and cattle and to the discovery of a new blood parasite, a *Hæmogregarine*, in the jerboa or desert rat. A somewhat similar parasite has also been found in the Norway rat. A full account is given of these researches. Mosquito work has been steadily continued, some attention has been paid to bilharziosis in the Sudan, and there has been a great deal of clinical work for the hospitals and sanitary work for the town generally. Insect pests and grain diseases have also come under notice and the value of zeers as bacteriological filters is at present being determined.

Extension of premises

I have to report that there has been an extension in the premises. The Director of Education kindly granted the use of two extra rooms. One of these has been converted into the Director's office and accommodates the library; to the other which adjoins it the laboratories' museum has been transferred. It is thus next the kitchen and preparation room and is more conveniently situated, while the re-arrangement has enabled the old museum room to be attached to the Chemical Department. Dr. Beam has fitted it out as a water analysis room and place for standing apparatus, and there is no doubt it was urgently needed. He has also altered and re-furnished the main Chemical Room to meet his requirements.

Special grant

This year the laboratories were fortunate enough to receive a grant of £E 322, which enabled special chemical apparatus to be obtained and new books and periodicals purchased. Some bacteriological equipment was also added and breakages were made good. Our small annual contingent was quite insufficient to meet these necessities.

The library

The library, though still far from perfection, is fairly well supplied, and the number of scientific journals taken in or presented has undergone considerable addition.

Progress of the Museum

The museum has markedly increased in pathological material, biting flies, ticks and mosquitoes. Not many new native drugs have been added. A few were sent by Captain Ensor from Suakin. It is impossible to mention all those who have benefited the museum, but I would like specially to thank Colonel Penton and Colonel Hunter, the past and present Principal Medical Officers, Major Bray, Captain Nickerson and Captain Hughes for specimens of biting diptera, and Major Dansey Browning, Mr. Crispin, Mr. Waterfield, and Captain P. E. Vaughan for valuable pathological material. Mr. Crispin has also furnished interesting photographs of various diseases. I regret that the beautiful series given by Dr. Christopherson during the first year of the laboratories' existence has not been further augmented.

Colonel Griffith, Captain Head and Mr. Thomas have continued generous donors and there is quite a respectable veterinary pathological department now in existence. Mrs. Broun has rendered much valuable help in the identification of ticks, many of which were sent by Mr. Gorringe. Sir Rudolph von Slatin kindly presented a goat showing an interesting malformation.

Gifts to the laboratories

Other gifts have to be recorded. Besides elastic dust-proof Bookcases for the library Mr. Wellcome presented a valuable Stereoscopic Camera—a most useful apparatus, in view of Dr. Beam's ability as a photographer, while the outfit which he provided for Dr. Neave's expedition was most complete and comprehensive in every respect.

Mr. Macmillan, at the close of his Expedition, very kindly handed over a fine Zeiss microscope adapted for photographic work. It has proved of great service.

It is again a pleasure to state that medical officers stationed in Khartoum have freely

availed themselves of such advantages as the laboratories offer, and have done a considerable amount of work in them.

Major Erskine, Captain Jameson and Captain Evans have all been frequent visitors, while the officers of the Egyptian Medical Service, and especially Major Dansey Browning, have often attended for purposes of work and study.

As regards the future, two things stood out clearly. The laboratories required more money and a certain increase in the Staff. I accordingly applied for an increase in the contingent, which had become quite inadequate. The laboratories are growing and require to be fed, otherwise their constitution will suffer. Similarly the work is growing and requires to be tended, otherwise there is a danger of its being neglected and much valuable material may be lost.

Dr. Beam required an assistant in the Chemical Department. Much of his time was taken up in preparing standard solutions and in the trivial but important details which should fall to the lot of a trained assistant. Mr. Friedrichs is kept constantly employed in bacteriological and museum work, and native helpers have so far proved to be broken reeds. They cannot be trusted beyond the bottle-washing stage. I am very glad to say that both my applications were granted. The laboratories contingent was increased and Mr. J. A. Goodson arrived at the beginning of this year as assistant in the Chemical Laboratory.

Increase in funds

Appointment of chemical assistant

An Economic Entomologist to take entire control of the insect pest work, to study the conditions both in the field and in the laboratory, and to carry out experimental research, would not only fill a vacant place in the Staff but would be of great benefit to the country. Every year taxes, amounting to large sums, have to be remitted owing to the ravages of the *Aphis sorghi* and other pests. There is a great deal of work to be performed, but it is special work and would take up the whole of a man's time. As much as possible has been done in the laboratories and some progress has been made, but the possibilities are great if funds can be found for such an official who might also conduct valuable researches as regards the breeding habits of *Glossina* and other biting Diptera. He has been applied for, and I hope may be appointed.* I saw something of what was being carried out in Egypt in this direction and it was very hopeful. The Sudan offers a large and even more interesting field of study, while it is a poorer country and cannot so well afford to be robbed by these enemies of the husbandman. We have again had the benefit of Mr. Theobald's knowledge, both as regards mosquitoes and insect pests, and Mr. Austen has rendered much valuable aid with reference to biting flies. Well-nigh three years' experience has convinced me that if a floating laboratory were attached to the Department a great step in advance would have been taken. The Southern Sudan is a country seamed by water-ways, on the banks of which are clustered native villages wherein all manner of rare and interesting pathological conditions are to be found. Flies and mosquitoes abound, the birds, reptiles and fish harbour strange parasites, men die from curious diseases, there is a vast field for the study of Tropical Medicine. Material occasionally reaches us in Khartoum from these distant regions, but it is too often in a damaged state. Blood slides are dirty and spoiled, insects broken, notes incomplete. If the conditions could be studied locally in a proper manner, I am certain that much of value could be garnered. I have tried doing blood work and microscopic work in a native hut, and it is most disheartening. Dr. Neave had similar experiences. A laboratory,

Value of an Economic Entomologist

Value of a Floating Laboratory

* Permission was obtained for the immediate appointment of such an official, and Mr. Harold King, of the South Eastern Agricultural College, Wye, England, has been elected to the post.

either on a barge towed by a launch, or on a small steamer would be an excellent way of meeting the problem. If Sleeping Sickness spreads from the Congo it would enable good work to be done on the Jur river and in other parts. Captain Greig agreed that it would be the proper way to conduct the study of trypanosomiasis and malaria in this country.

Further, it would enable economic inspections to be readily made. The sites of salt and lime deposits, the fields ravaged by insects, and certain of the gum districts could be readily visited and much of the necessary work done on the spot. The same is true if epidemics scourged the river banks. It is very difficult to transport pathological material in the Sudan. Given a floating laboratory and this would be obviated in large measure save as regards museum specimens. If such a barge or steamer can be obtained Mr. Wellcome has signified his willingness to fit it out as a laboratory.*

Future investigations

There are various lines along which it is intended to pursue investigations given time and opportunity. The bacteria and protozoa of Nile water should be studied. The origin of that common and crippling disease, Mycetoma, badly wants elucidation. So does the action of bacteria in the formation of gum, a line of work begun in Australia by Dr. Greig Smith. Guinea-worm infection is not fully understood. Trypanosomiasis is yet veiled in clouds of ignorance, especially as regards remedial measures. What should prove an interesting and valuable step has been taken at the instigation of Mr. Currie. The Trustees of the Carnegie Research Fund have been approached and they have agreed to recognise these laboratories as a working place for their Research Fellows. It is hoped that, before the end of 1906, two such Fellows will have been appointed to conduct investigations in the Sudan, the one working on chemical, the other on bacteriological or pathological lines.

Adverse climatic conditions

It will be seen there is much to be done, and it must be confessed the Sudan has its disadvantages as regards scientific work. Heat, wind and dust are our chief adversaries. The accompanying remarkable photograph of a haboub, or dust storm (*see* Fig. 2, *page* 8), sweeping over Khartoum North, in June 1905, and taken by Dr. Beam, gives some idea of the climatic troubles which at times have to be faced during the trying summer. Hence progress must be slow, and improvements are required, such as double windows, electric fans and electric light, dust-proof rooms, efficient ventilation, &c., but no doubt these will come in time, and things are very far from being unsatisfactory. Above all, the support and help rendered one by many officials lightens the difficulties and encourages the worker. As before, I have to thank the Director of Education and his staff for much kind aid, while various scientific departments in other countries, such as France, the United States, South Africa and Australia, have helped us with literature and advice. My hearty thanks are also due to the laboratories' staff for their co-operation and support, and to all those who have favoured us with specimens and information.

Foreign aid

* It gives me much pleasure to state that this request has also been favourably considered and that ere long a floating laboratory will be at our disposal.

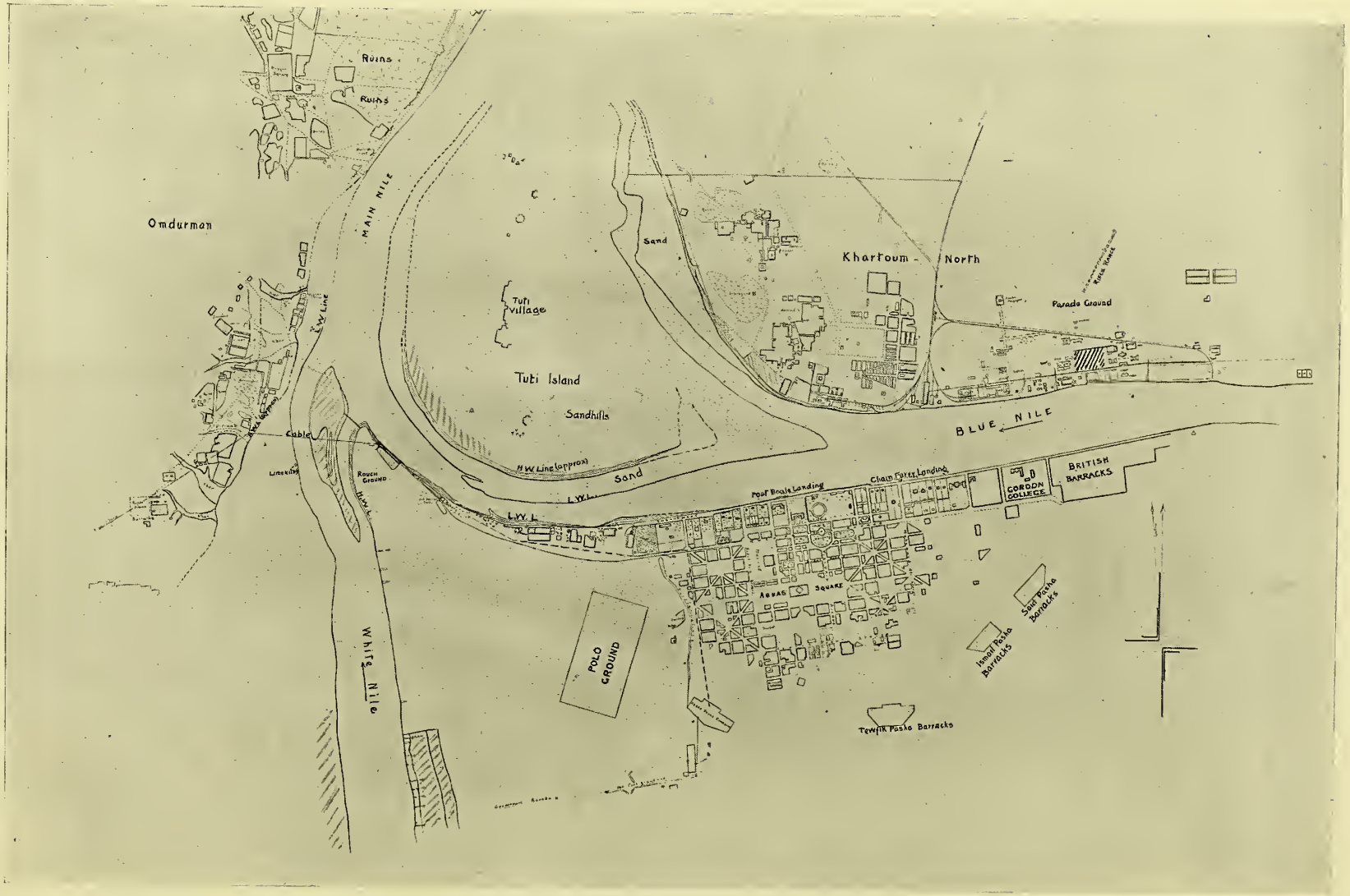

FIG. 3.—PLAN OF KHARTOUM AND ENVIRONS, showing Khartoum North and Omdurman, and the relations of these three towns to the Blue and White Niles. The surrounding country in all cases consists of bare desert land

Mosquito Work in Khartoum and in the Anglo-Egyptian Sudan Generally

In the First Report of these Laboratories an account was given of the starting of a mosquito brigade, and of its operations.

It was shown that 50 per cent. of the total water collections in Khartoum were found to be infected, and that six months' work reduced this number to 9·5 per cent., and in addition caused the disappearance of Anophelines, and a great lessening in the number of Stegomyia.

These results were so encouraging that it was decided to continue the brigade, and to bring Khartoum North into the sphere of operations. This was done in March, 1904, and I am now able to give a nearly complete list of statistics of mosquito reduction for Khartoum and Khartoum North. As previously pointed out these figures make no pretence at absolute accuracy, but they closely approach the truth.

Increase in sphere of operations

The term water collection is a somewhat arbitrary one. It includes all wells holding water in which mosquitoes might breed, rain-pools of sufficient size or depth to remain for a period of at least one week, similar pools left by the falling Nile, the syphon pits of irrigation channels, or pools formed by leaking channels, permanent garden pools or ponds, and bath waste-pits.

Definition of the term "water-collection"

Zeers, fire-buckets holding water, and similar collections which cannot be regarded as permanent, are not counted in the monthly returns unless found infected.

This method is about the most satisfactory that can be devised, and gives a fairly definite basis on which to work.

Collections in boats, barges and steamers are not included in these returns, though statistics are kept about them for purposes of reference.*

MOSQUITO STATISTICS—KHARTOUM, 1904-1905.
Continuation from First Report.

Statistics, Khartoum

Year	Month	Total Water Collections	Infected					Percentage Infected	Remarks
			A.	A. & C.	C.	S.	Total		
1904	April ...	709	1	...	77	1	79	11·1	Operations began in Oct., 1903, prior to which, percentage infected was 50.
	May ...	713	...	...	56	...	56	7·85	
	June ...	703	...	...	31	...	31	4·26	
	July ...	689	...	...	25	...	25	3·63	
	August ...	689	...	...	43	...	43	7·02	Rise due to heavy rains and formation of pools.
	September	686	...	1	20	...	21	3·63	
	October ...	684	1	...	18	...	19	2·77	
	November	686	...	...	15	...	15	2·78	
	December	613	...	...	19	...	19	3·10	
1905	January..	652	...	...	18	...	18	2·76	

* In the tables A signifies Anophelines, C, Culices and S, Stegomyiæ.

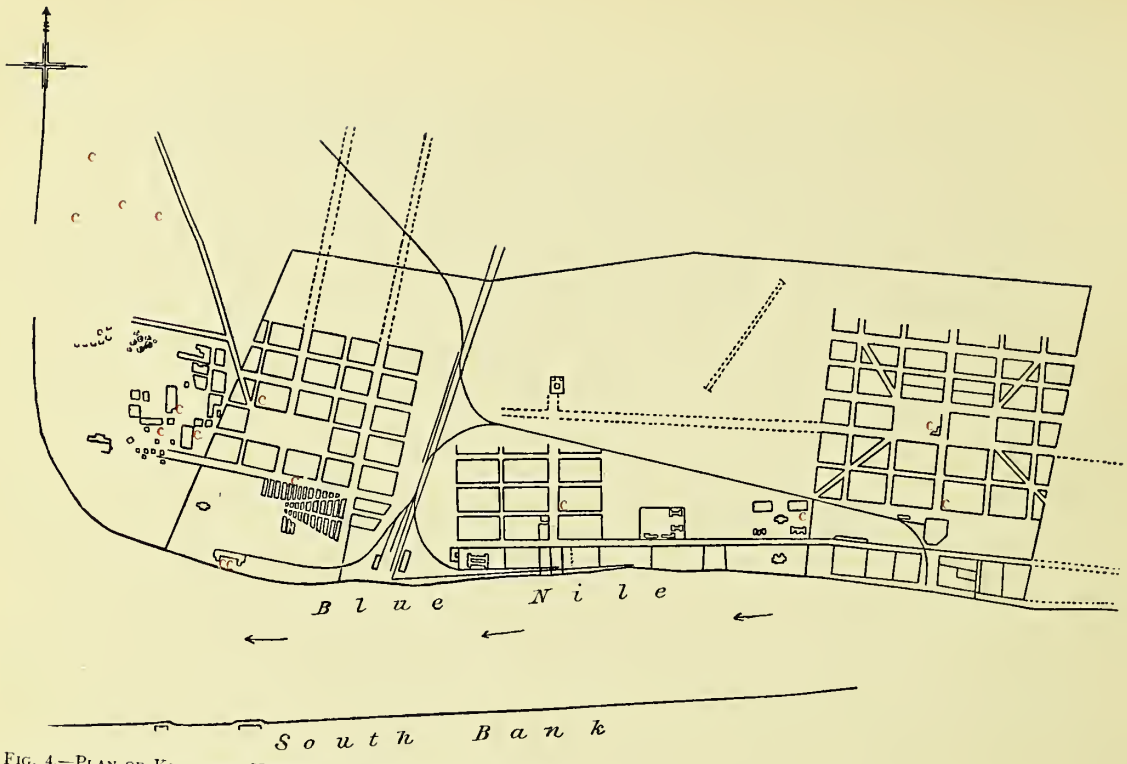

FIG. 4.—PLAN OF KHARTOUM NORTH, showing condition as regards Mosquito infection during March, 1904, before reduction measures had been adopted

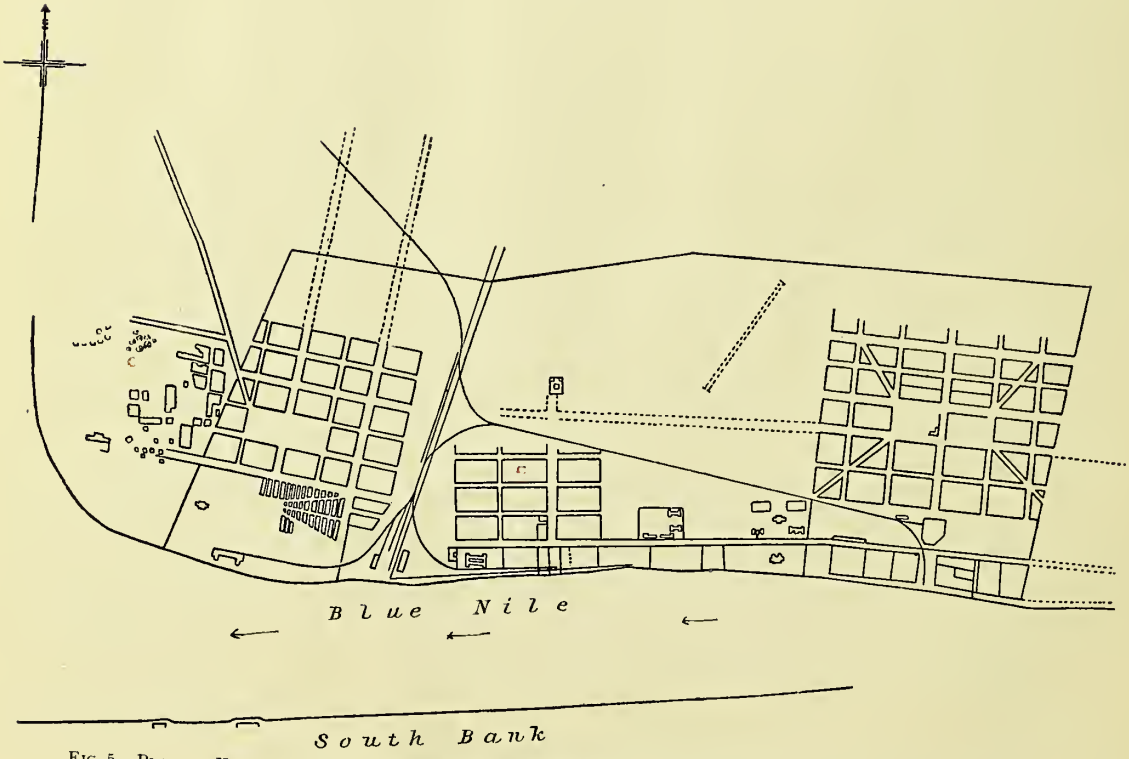

FIG. 5.—PLAN OF KHARTOUM NORTH, showing the most favourable condition obtained in mosquito reduction operations during November, 1904

MOSQUITO STATISTICS—KHARTOUM, 1904-1905—(*continued*).
CONTINUATION FROM FIRST REPORT.

Year	Month	Total Water Collections	Infected					Percentage Infected	Remarks
			A.	A. & C.	C.	S.	Total		
1905	February	658	...	...	19	...	19	2·88	
	March ...	666	...	...	26	...	26	3·88	
	April ...	676	1	...	17	...	18	2·66	Anophelines found in river pools.
	May ...	666	2	3	33	...	38	5·70	Anophelines found in river pools.
	June ...	666	1	...	12	...	13	1·95?	Statistics doubtful; temporary inexperienced inspector.
	July ...	666	1	...	17	...	18	2·70?	Statistics doubtful; temporary inexperienced inspector.
	August ...	680	1	...	42	...	43	6·20	Usual inspection resumed.
	September	684	...	...	33	...	33	4·82	-
	October ...	733	...	2	60	...	62	8·43	Heavy rains; many pools; coverings of wells washed away.

MOSQUITO STATISTICS—KHARTOUM NORTH, 1904-1905.
FROM COMMENCEMENT OF OPERATIONS.

Statistics, Khartoum North

Year	Month	Total Water Collections	Infected					Percentage Infected	Remarks
			A.	A. & C.	C.	S.	Total		
1904	March ...	56	...	...	15	...	15	26·78	Prior to operations.
	April ...	55	...	...	10	...	10	18·1	Operations began this month.
	May ...	55	...	...	6	...	6	10·9	
	June ...	55	...	...	5	...	5	9·9	
	July ...	59	...	...	9	...	9	15·2	Rise due to increase in unused wells and infection of leaking irrigation channels.
	August ...	59	...	...	6	...	6	9·8	
	September	59	...	...	6	...	6	9·8	
	October ...	59	...	...	2	...	2	3·4	Decrease due to wells being covered.
	November	59	...	...	3	...	3	3·9	
	December	59	...	...	4	...	4	6·8	
1905	January	98	...	...	5	...	5	5·10	Town rapidly extending; many new wells.
	February	98	...	...	4	...	4	4·08	
	March ...	100	...	...	6	...	6	6·00	
	April ...	103	...	...	5	...	5	4·85	Rain pools formed.
	May ...	98	...	...	4	...	4	4·08	
	June ...	100	...	...	3	...	3	3·00?	Statistics doubtful; temporary inexperienced inspector.
	July ...	100	...	...	2	...	2	2·00?	Statistics doubtful; temporary inexperienced inspector.
	August ...	110	1	...	7	...	8	7·27	Usual inspection resumed; leaking irrigation channels.
	September	113	1	1	4	...	6	5·31	
	October ...	115	1	1	4	...	6	5·21	Rain pools formed; syphon pits infected.

It will be seen that the town has been kept in a fairly satisfactory state, and one vastly different from that which used to obtain. Anophelines have been practically abolished, though we are always liable to their recurrence owing to outside infection, and, latterly, they have been somewhat persistent. If, however, prompt measures are taken as soon as they are found, they usually speedily disappear. The only instances where they remained for some time occurred in Khartoum, when river pools were forming and Mr. Newlove, the Sanitary Inspector, who has conducted the work with much energy, was absent on leave, and in Khartoum North. In the latter case the irrigation channels of certain barracks were in a leaking condition, and in the pools which had formed the Inspector found the larvæ of *Pyretophorus costalis*. He had the pools oiled, informed the person in charge of the occurrence, and received a promise that the necessary repairs would be executed. Unfortunately, he relied on this promise and did not again visit the spot till the time came for his customary round. For some reason the work was not carried out, the Anophelines bred freely, and what is remarkable is the fact that during this period several cases of primary malarial infection occurred amongst Egyptian soldiers in these barracks, all being men who had never been south of Khartoum. This shows the importance of proper supervision. Inspection is often very hot and tiring work in the summer, and Khartoum North is difficult to reach, but unless care be taken to see that instructions are really and correctly carried out, failure will frequently result. The simultaneous occurrence of Anophelines and malaria is very interesting. The same thing occurred at an earlier period in Khartoum. Anophelines were found breeding in small numbers, and at that time the solitary case of primary malarial infection seen by Major Dansey Browning and myself in Khartoum, during the winter of 1904-05, came under observation.

Simultaneous occurrence of Anophelines and Malaria

It is not justifiable to make a definite statement to the effect that malaria has decreased in Khartoum, because no statistics are available whereby this can be proved. Malaria is a disease which often can only be diagnosed with certainty by blood examinations and there are no records of such in the past. We do not know exactly how much malaria previously existed in Khartoum though we can now obtain some idea of how much exists at the present time. There is a very general opinion, however, that cases of "fever" have diminished, a supposition supported by the experience of those responsible for the health of the large garrison which contains many highly susceptible Egyptians. There can be no doubt that primary malaria is now rarely encountered in Khartoum. As, heretofore, numerous cases of the disease came into the city from both Niles, while cases of recrudescence of old attacks are not uncommon, but the carriers are usually absent and hence the parasites are not transferred from the sick to the healthy. I have not seen a living, wild, adult Anopheline in Khartoum for more than a year and a half and I am always on the outlook for these insects.

Diminution in cases of "fever"

It is instructive to examine old records. Thus Schweinfurth* writing of the year 1871 and describing his return to Khartoum says: "In spite of everything, however, the sanitary condition of Khartoum was still very unsatisfactory. This was entirely owing to the defective drainage of that portion of the town which had been built below the high-water level. In July when I was there I saw many pools almost large enough to be called ponds that could never possibly dry up without the application of proper means for draining them off; stagnant under the tropical sun they sent forth such an intolerable stench that it was an abomination to pass near them. When it is remembered that Khartoum is situated in

Schweinfurth on the unhealthiness of old Khartoum

* The Heart of Africa, Vol. II., p. 279.

the desert zone (for the grassy region does not begin for at least 150 miles farther to the south), there can appear no necessary reason why it should be more unhealthy than either Shendy or Berber; all that is wanted is that the sanitary authorities should exercise a better management and see that stagnant puddles should be prevented. As I have already intimated I found that, during my absence, not a few of my former acquaintances had fallen victims to the fatal climate." How suggestive are these passages! In those days the rôle of the mosquito in malaria was unknown. It was not the stinking and evaporating puddles which were to blame, though they may have played a subsidiary part, but the Anophelines bred out in them.

That Schweinfurth's friends died of malaria there can, I think, be little doubt, and I regret to say that given a wet summer, and it is said comparatively wet summers may occur in Khartoum, there is nothing to prevent a similar state of matters arising at the present time. Khartoum has been rebuilt, and much has been done to render it a healthy city, but there has not yet been time to have its site properly levelled or drained. Because of recent years the seasons have been dry it has not been necessary to cope seriously with flooding by heavy rains. There are no surface drains, the centre of the town lies in a hollow; there are many depressions. That pools readily form and may persist for a long time I have myself observed. In October, 1905, very heavy rain fell for about an hour and a half, amounting in all to 1·8 inches. The pools formed by it persisted in some cases for from twelve to sixteen days and finally had to be emptied by a fire pump. Fig. 6, *page* 20. Under favourable circumstances *Pyretophorus costalis* will pass through all its water stages in a little over a week.

Danger of flooding and ponding

What is to occur if we get repeated showers of torrential tropic rain distributed throughout several months? I have no hesitation in saying that malaria would occur and possibly run riot. Our little mosquito brigade could never cope with the conditions, special working parties would fail to get rid of all the water in time, the amount of oil necessary would be enormous, and it would be blown into heaps at the ends of the pools. Anophelines would invade us from without and the sickness rate would certainly rise. Observe the statistics given! It is always after rain that more mosquitoes are found. In part this is due to the fact that the rain often washes away the soil from under the edges of the well covers, leaving holes whereby mosquitoes can gain entrance, while it also causes old wells to fall in, and water collecting at the foot of them, forms very favourite breeding places. Anophelines, however, rarely breed in wells, and they are very fond of pools and puddles. The remedy is obvious. Although it may appear to some that I am merely advocating a waste of money, I believe that Khartoum should either be drained or the levels improved. At present efficient drainage would be best. No one can say when a comparatively wet summer may deluge the town. The Blue Nile can be kept out, the rain cannot, but it can be removed, and provision for its removal should be made. The town is to be given a water supply, and when this is an accomplished fact better provision will have to be made for the disposal of slops and waste waters. Whatever scheme be chosen it might be adapted to deal at the same time with storm waters though admittedly the problem is a somewhat difficult one owing to the lack of fall in certain directions.* While discussing this subject one may consider whence the invading Anophelines come and how they reach Khartoum. I believe they are usually bred out in the pools which form in

How rain acts

* It is satisfactory to note that this question is now under discussion and schemes for dealing both with storm-waters and waste-waters are being considered.

the terraced banks and sand-banks of the Blue Nile above the town. The mosquito brigade is so small, there is so much to be done, and there are such few means of transit that it is difficult to control a large area, or rather lengthy strips, outside the town boundaries. It can be done and is done as far as the limiting White Nile on the west, but on the east side it is more difficult, and thus it happens that every now and then pools or other water collections escape inspection, and mosquitoes are either driven into Khartoum by the wind or brought to it in boats and steamers. Occasionally Anophelines have been found breeding out in leaky boats or on board steamers, in water accumulations which are exposed to the light. As previously stated, they do not breed in the bilges. At present, however, it is comparatively easy to locate them in the town

Invasion by Anophelines

Fig. 6.—Pools in Khartoum.—These pools were formed by a rainfall of 1·8 inches, and one hour, thirty minutes' duration. Some persisted for over three weeks in October, 1905.

at an early period, and to cut short their career, but it would be a totally different business if Khartoum was studded with ponds and pools. The belief above expressed has quite recently received remarkable but unwelcome confirmation. The fast of Ramadan was followed by the feast of Bairam. The first lasted four weeks, the latter one week. Both—and especially Bairam—interfered with the work of the brigade. The men worked badly during Ramadan, they would not work at all during Bairam. The Blue Nile was falling, and the pools shown in Figs. 7 and 8 (*page* 22) formed in the sandbank above the British barracks. No doubt the cold weather which obtained was the cause of a recrudescence of a malaria attack in a soldier who had served in India and was resident in these barracks. Seven other cases quickly occurred. Attention was directed to the pools, and *Pyretophorus costalis* was found

Malaria outbreak amongst British troops

breeding in some of them. The larvæ were destroyed wherever found, and the cases came to an end. At no time were adult winged Anophelines found, but these must have existed in small numbers and undoubtedly caused the limited epidemic.

In the future the desert land round both Khartoum and Khartoum North will, no doubt, be irrigated. Herein lies a great danger to the health of the community, and one would strongly advocate the preservation of a so-called "dry zone" behind both parts of the town. It should be at least one mile in width, that is to say, a mile of perfectly bare dry land, a sandy stretch, wind-swept, and affording no shelter to mosquitoes, should be left between the farthest likely extension of the town and the irrigated area. The necessity for such dry zones has been strongly urged in India, especially at Madras,* while in Italy their establishment is enforced by law. As is pointed out by Major King, it must ever be a case of asking, "Is the game worth the candle?" Personally I think it is—at least, as far as Khartoum is concerned—while a somewhat modified scheme might be adopted for Khartoum North, where admittedly the difficulties are greater. I have heard it said that the mosquitoes are preferable to dust, but such dry zones would never be productive of much dust, and surely none could prefer mosquitoes plus malaria, and possibly plus dengue, to the small amount of irritating and annoying dust derived from such dry strips. Of course, a great deal will depend on the type of irrigation employed.

Necessity for "dry zones"

One has read with much interest Professor Ross's address† on the subject of "The logical basis of the sanitary policy of mosquito reduction." I believe that if one had time to devote to it, the matter could be studied excellently well in Khartoum. Conditions are specialised and simple, the area to be exploited is limited, so are the species of mosquitoes to be studied. I have had no leisure to go fully into the matter, but I am inclined to think that the results obtained here support certain of Professor Ross's conclusions, and especially the one which states that "as a general rule for practical purposes, if the area of operations be of any considerable size immigration will not very materially affect the result."

In Khartoum, however, it must not be forgotten that the subject is complicated by the presence of mosquito-carrying steamers, boats and barges. Were it not for these, greater success would have crowned the efforts at extinction, or rather reduction.

It may be asked why operations conducted for so long a period have not resulted in the almost total extinction of mosquitoes in Khartoum. The reasons are not far to seek. They are to be found in the immigration already considered, in the smallness of the brigade and of the funds at our disposal, in the carelessness of householders and others as regards well covers, the cleaning of zeers, and the repair of irrigation channels, and also to the imperfections to which all human labour is liable, and which are always more numerous when the conditions are tropical and the workers coloured natives. There has to be constant vigilance, and one must be prepared to make complaints and excite grievances. Memories must be jogged and offenders punished if any success is to accrue. It is often wearying and disheartening work, but it is worth doing, for the issues at stake are not trifling. Still we are rid, and well rid, of the annoying Stegomyia, the dangerous Pyretophorus is kept in abeyance, and Culex, the ubiquitous, has ceased to be a nuisance.

Causes of want of complete success

The work is being conducted on much the same lines as hitherto. Native inspectors are fined if pupæ are found in water collections under their care. The amount of oil used per well

* King. Indian Medical Gazette, June, 1905, Vol. XL., p. 201.

† Ronald Ross. Brit. Med. Jour., May, 1905, Vol. I., p. 1,025.

FIG. 7

FIG. 8.—POOLS LEFT BY THE FALLING BLUE NILE IN THE SANDBANK EAST OF THE BRITISH BARRACKS, KHARTOUM. Anophelines bred out in these pools. The shrunken river channel is seen in Fig. 7.

has been reduced to half-a-pint. This is still much in excess of what is actually required to kill the larvæ. Two ounces have been found to be ample, but the larger quantity is employed because some is wasted owing to splashing, and because it admits of a film being formed which lasts for several days in the case of a well and prevents reinfection.

Several interesting new facts have come to light. Thus, wells which are constantly in use are very rarely infected by Culices. It is the unused well that is the great nuisance, and very often the unused well is in the unoccupied and locked-up premises, and therefore difficult of access. Sometimes a used and unused well have been found alongside each other, the former uninfected, the latter harbouring eggs and larvæ. Sir William Macgregor, till lately Governor of Lagos, wrote me from Newfoundland, asking if the depth of the wells had any influence on the breeding operations, as he had made some observations on this point in the West Coast territories.

Unused and deep wells

FIG. 9.—DEVELOPMENT OF MOSQUITOES. LARVÆ, PUPÆ AND IMAGINES. Both Culex and Anopheline larvæ are shown, the former only possessing respirating syphon tubes.

In Khartoum the deepest wells do not exceed 30 feet from ground level to water surface, and *C. fatigans* seem to breed indifferently up to that depth. The wells at Omdurman are much deeper. In one of these, at a depth of 70 feet, the larvæ of both *C. fatigans* and *P. costalis* were found. It was an uncovered well worked by a pump, and it is remarkable that Anophelines were found in it, for there could be but little light at that depth, and as stated, *P. costalis* does not favour wells.

FIG. 10.—EGG-BOAT OF CULEX. The straight line indicates the level of the water.

So far it has not been possible to attack the mosquitoes in Omdurman. The area there is too vast, it is out of the way, few Europeans live in it, and the distance between it and Khartoum is, I think, too great for infections of the latter town from the former to occur with any frequency, save, indeed, when the inevitable steamer serves as an intermediary. Still the task should be undertaken, but it is largely a question of ways and means. Dr. Doty's recent investigations* go to support the view that the mosquito is not much of a voluntary traveller. It is worth noting that the wind very rarely blows from Omdurman to Khartoum, *i.e.*, from the north-west. The reverse is the case in the summer, while in the winter north-east or due north winds prevail.

Considerations regarding Omdurman

Considerable improvement has resulted from having as many wells as possible covered over, permanently if a pump is affixed, with a movable wooden cover if the water is drawn by hand. Wooden covers are very liable to warp and split in this country, but they can be easily repaired. An attempt was made to procure covers of canvas or sacking fixed to barrel hoops, like those used with success at Bathurst.† In Khartoum they cost too much, chiefly because barrels are rare articles in the Sudan, and special flexible metal had to be

Covering of wells and the introduction of pumps

* Brit. Med. Jour., Vol. II., 1905, p. 971.

† Dutton. Report of the Malaria Expedition to the Gambia, 1902, p. 36.

procured, also because labour is better paid. What cost fourpence in Bathurst actually cost three shillings and sixpence in Khartoum, and was not good at that!

It used to be the rule that anyone might sink a well practically anywhere in Khartoum, and when he had finished with it, he left it as it was. This state of things has been altered. Now no one may sink a well for any purpose without submitting a plan, showing the situation of the proposed well, to the Governor. Such plans are passed to the Medical Officer of Health. The well may or may not be sanctioned, but if it is, the owner is made to promise, under penalty for default, that he will either fill in the well when no longer wanted, if it is being sunk merely to secure water for building purposes; or if it is intended for prolonged use, that he will affix a cover to the satisfaction of the Sanitary Inspector, and that he will keep that cover in good repair. This has been productive of much benefit, though it requires constant watchfulness to see that the law is not evaded, The cost to the owner or user is not great, though in some cases it may constitute a hardship. The covers may be fixed, and then stolen or maliciously broken. It is almost impossible to attain anything like perfection in this vexed question of wells, but every little helps. Public wells are all covered and most of them have pumps.

Registration of wells

When Khartoum possesses a proper water supply with stand-pipes in the streets it is proposed to fill in all the wells save such as are required for the irrigation of gardens. If this be done *C. fatigans* will find it very difficult to maintain a footing in the town. The rapid extension of Khartoum has recently necessitated the sinking of many new wells for building purposes. These have to be permitted, but one is sorry to see the site of the town honeycombed in this way.

Proposed future action

For a long time it was difficult to control the breeding places on the steamers, but in the autumn of 1904 the Director of Steamers and Boats issued more stringent regulations to engineers and native reises, and the result was soon apparent. Steamer after steamer arrived free from mosquito larvæ, Khartoum North became a more comfortable place of habitation, and the wells in the river zone of Khartoum were less frequently re-infected. The engineers were taking trouble and carrying out the plan which had been devised for treating bilges both in the steamers and in the sandals or barges they are accustomed to tow.

Steamers and boats

The following are the instructions which were issued. Mr. Newlove devised the plan of oiling the wood holds in rotation. They had always been a difficulty till this was done.

Regulations for steamers and boats

"1. Before leaving Khartoum the bilge water in the various sections should be oiled by pouring petroleum on the surface of the water and stirring well with a stick. A film will then form on the surface which prevents access of air to the mosquito larvæ and pupæ and so kills them. Eggs deposited by mosquitoes on this oil film will not develop, and many of the females themselves will be killed. Roughly about one-half pint of oil should be devoted to each section. A little experience soon shows how much or how little oil is needed to form a proper film. In addition, the water in the trays under the boilers should be examined, and if necessary, oiled. (This note was added because Anophelines were found breeding in such water.)

"A cup or wide-mouthed bottle can be used for collecting water for examination. The vessel should be quickly but gently dipped under the surface and lifted out without spilling any of the contents. For somewhat inaccessible places a tin with its bottom replaced by wire gauze mesh and attached to a stick is useful. The larvæ are then found wriggling on the gauze. Such a collecting dish is easily made and answers well. It should be examined

in a good light. It is to be remembered that any standing water collections will harbour mosquito larvæ, and attention should therefore be paid to the water-closet cisterns, zeers and tanks.

"2. During the voyage, opportunity should be taken to re-oil the bilges wherever possible. This should especially be the case before starting on the return journey. Wood holds are usually at fault. The difficulty can be got over by emptying these in rotation so that the water in the hold can be got at and oiled once in every fortnight. Special attention should be directed to zeers when these are used for storing bottles of drink. All zeers should be emptied out at least once a week during the voyage.

"3. The thing to be avoided is returning to Khartoum with mosquitoes on board. If this is done, wells and water collections in the town which have been cleared at trouble and expense, are liable to become re-infected. This has happened repeatedly so that it is very important that steamers should arrive clean and free. It is well to have all bilge water emptied on arrival, and all steamers lying up should be inspected and treated in the manner described. Similar precautions are required as regards barges, sandals, launches and any vessel on which there is stagnant water.

"*Note.* It has been proved that mosquitoes, as a rule, will not stay for any length of time on a steamer if they are prevented from breeding out on board. Consequently, such preventive methods are effective as has been demonstrated on several occasions, and there is no excuse, in most instances, for steamers reaching Khartoum with their bilge water, &c., full of larvæ and pupæ, and their cabins full of adult mosquitoes."

Sometimes it has been found advisable to employ sulphur squibs* when there were many adult insects in the holds.

It is largely due to the efforts of Mr. Potts, of the Steamers and Boats Department, that the local launches, barges and ferry-boats have been kept free. Only those who have had to deal with the laziness, procrastination and inattention of the natives in charge of some of these craft, can realise how difficult his task has been, and how well he has carried it out.

The Director and Assistant-Director of the Steamers and Boats Department have done all in their power to help the mosquito brigade, and consequently great benefit has ensued, despite occasional relapses. The manager and officials of the Sudan Development and Exploration Company have also, as a rule, done their utmost to keep the Company steamers free. The British Barracks are, in the main, looked after by the Medical Officer in charge of British Troops. They are, as a rule, kept perfectly free, though it is worth noting that they are rather subject to re-invasion by Anophelines—confirmation of the statement that these mosquitoes invade the town from the east.

The British barracks

It is interesting to find that the natives have developed a great liking for petroleum. They seem to regard it as a panacea for every kind of winged pest, and use it to keep away flies and midges. This is a curious testimony to the efficacy of Major Ross's method.

No new genus or species has been found in Khartoum. Indeed the only constant species now present is *C. fatigans*. *P. costalis* is an infrequent, but none the less unwelcome, visitor. *Stegomyia fasciata* has given up the struggle, and, as far as can be told, has not been present for many months. It used to be a nuisance in the middle of the day. It is difficult to say whence came the solitary *Mucidus* mentioned in the last report. It is the only representative of this mouldy-looking genus yet discovered in the Sudan. Possibly the *Theobaldinella spathipalpis* were introduced by the train, as they were found breeding near

* Giles. Gnats and Mosquitoes, 1902, p. 221.

the station. The cisterns on the trains have been occasionally examined, but always with negative results.

Cost of operations

We are now in a position to estimate the cost of these operations. Practically the only expenses which have to be considered are the wages of the men of the brigade and the cost of the oil employed.

Expenses for 1905.

No.	Item.	£E.	Mms.
1	Headman, at 120 piastres per month...	14	400
1	Man at 100 piastres per month (three months) ...	3	—
2	Men at 80 piastres per month (three months) ...	4	800
2	Men at 100 piastres per month (nine months) ...	18	—
80	Tins of Petroleum, at 16 piastres per tin (for town)	12	800
70	Tins of Petroleum, at 16 piastres per tin (for Steamers and Boats)	11	200
30	Tins of Petroleum, at 16 piastres per tin (for Works Department Barges)...	4	800
	Total	69	. 000

Note.—The Egyptian pound is equal to £1 0s. 6d. of English money; there are 100 piastres in the £E1 and 10 millièmes go to the piastre. The oil tins each hold four gallons.

The Sanitary Inspector is paid nothing additional for the mosquito work which constitutes some of his most important duty; the initial outlay was very small—not more than £E3, and the only other expenses are those incurred in crossing and recrossing to Khartoum North—a mere trifle. True, this is the second year of operations, but the work has been much extended, and the estimate is a fair one.

Therefore, for something considerably under £100 per annum, Khartoum is kept practically free from malaria, and the inhabitants are secured, to a very great extent, from the persistent and annoying attentions of these winged pests, which, as a rule, add so much discomfort to life in the tropics. I do not think the above is a large sum to pay for such immunity.

New genera and species found in the Sudan

As has been stated, no new species have been found in Khartoum, but one is able to announce "finds" made elsewhere.

Colonel Penton discovered *Ædiomyia squammipenna* on the Jur river and *Cellia squamosa* at Meshra-El-Rek, on the Bahr-El-Ghazal. No *Ædiomyia* has been taken before or since in the Sudan, and the genus *Cellia* had been represented only by *C. pharœnsis*. *C. squamosa* is probably a malaria carrier.

Dr. Neave made a considerable collection, which included two new culices. These are described by Mr. Theobald. Mr. Newlove obtained a very fair collection, in which occurred a fine purple variety of *Culex tigripes*, also secured by Colonel Penton. Mr. Newlove also collected some larvæ new to science, which have also been submitted to Mr. Theobald.

Captain Hughes sent *Culex hirsutipalpis* from El Obeid, where *P. costalis* seems common, and Captain Ensor and Mr. Crispin have shown that *Stegomyia fasciata* is the chief mosquito at Suakin.

Mr. Friedrichs was sent up the Blue Nile to Roseires in September, 1905. Amongst the mosquitoes which he brought back I found *Myzomyia funesta*, represented chiefly by

the variety *subumbrosa*, to be numerous. This well-known malaria carrier had not previously been found on the Blue Nile. Three malaria carriers are now known on that river, namely, *Pyretophorus costalis*, *Cellia pharœnsis* and *Myzomyia funesta*. Mr. Friedrichs also secured a new and beautiful species of Mansonia, named *nigra* by Mr. Theobald. It may yet constitute the type of a new genus. Major Bray brought a small, but good collection of *Culicidæ* from the Bahr-El-Ghazal province which included a mosquito representative of a new genus, *Quasistegomyia*.

A tree-breeder

He also sent some useful notes describing how he found mosquitoes breeding out in water collections in hollow trees, a fact first elicited by Lütz in South America, and he records the remarkable observation that mosquito larvæ destroy the young fry of fish. Murray has shown that adult mosquitoes do so, but I am not aware that anyone has hitherto found the larvæ so engaged.

In January, 1905, I went to Taufikia on the White Nile, and at Goz-Abu-Guma found the missing male of *Uranotœnia balfouri*, several females of this species, and a curious mosquito with an expanded proboscis, which I sent to Mr. Theobald. It appeared to me to be a *Mimomyia*. I found *Cellia pharœnsis* as far north as Goz-Abu-Guma, while at Renk *Myzomyia funesta* and *Myzorhynchus paludis* were taken. In all, sixteen different genera comprising some thirty-five species of *Culicidæ* have now been found in Sudan territory.

I regret to say our knowledge is no further advanced as to which of the species of Anophelines found are capable of serving as hosts in the mosquito-man cycle of the malarial parasite. Not every Anopheline can carry malaria, as witness *M. rossii* in India, so that it is very important to determine accurately those which are pernicious. Of the Nile Anophelines *Myzomyia funesta*, *Pyretophorus costalis* and *Cellia pharœnsis* are known to be implicated in the traffic, but dissections of *Anopheles wellcomei*, *Myzorhynchus paludis*, *Myzomyia nili*, *Cellia squamosa*, and any new Anophelines are required. It is possible that *Myzorhynchus paludis*, which is rather a different type of mosquito from the others, and does not bite as freely, may escape having to bear an evil reputation, but one cannot tell without making careful experiments and examinations. Probably *M. funesta* is the worst of the batch. These Anophelines are found far from Khartoum, and I have had no opportunity of studying them properly. In this connection one may record a few facts about malaria itself. Further experience has somewhat modified my view that the quartan parasite is rare. It is not so common as the other two recognized varieties, but it occurs with considerable frequency. For example, of the last 50 consecutive cases which I examined, thirty-three were malignant (small ring forms or crescent), eleven were benign tertian, and six were quartan. Ten of these 50 cases came from up the Blue Nile and of these ten, six were malignant, one was benign tertian and two were quartan. The remaining cases came from the White Nile and Bahr-El-Ghazal, with the exception of a few occurring in Khartoum. It is curious that I have never seen a case with many crescents in the peripheral blood. Severe crescent infection does, however, occur, according to Major Rivers.

Necessity for determining which of the Anophelines carry malaria

Malaria statistics

The figures given are of some interest, but no conclusions can be based on so small a number of cases, and in the absence, in many instances, of information regarding previous history.

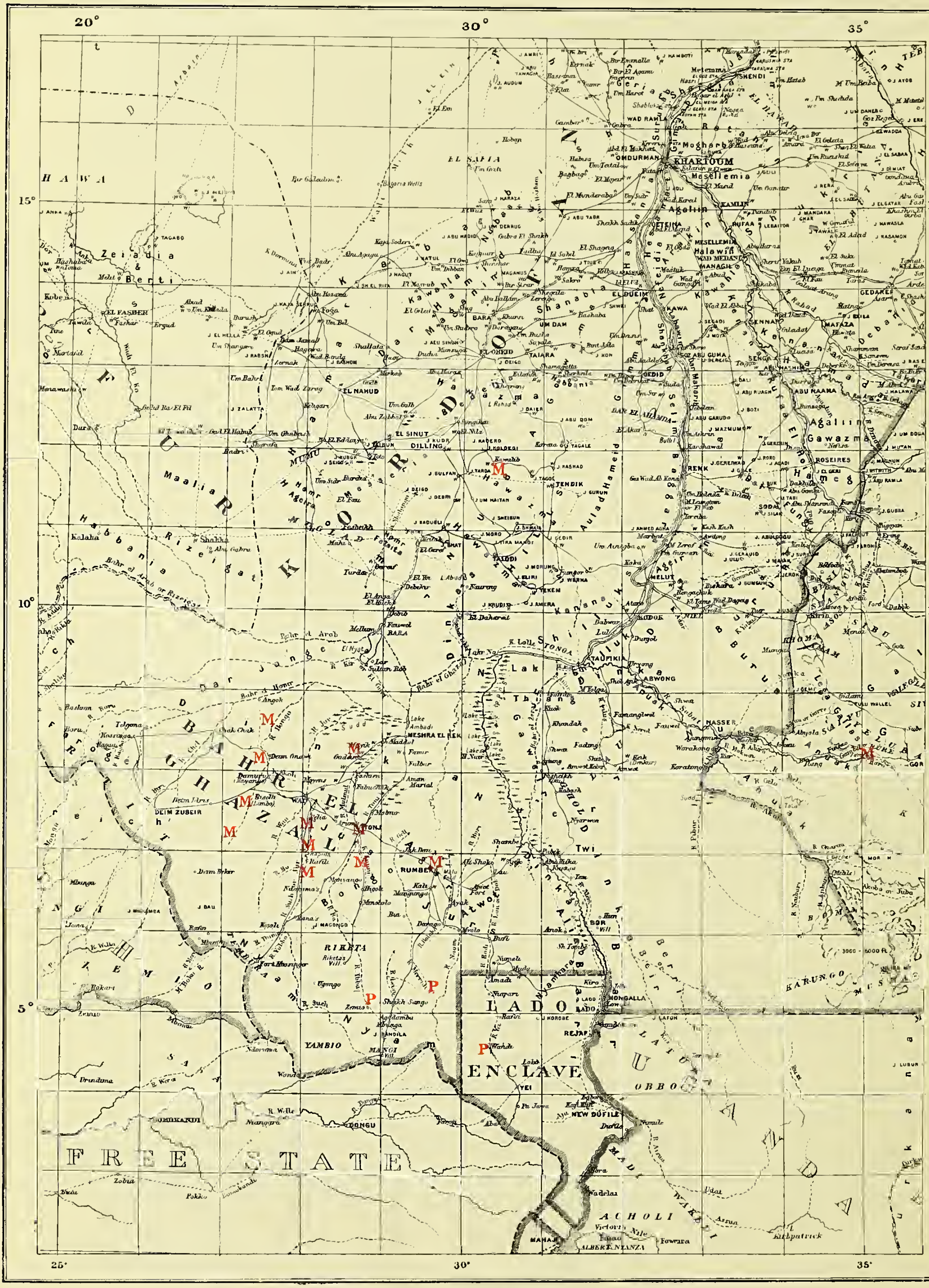

FIG. 11.—TSETSE FLY MAP
M. Glossina morsitans. P. Glossina palpalis.

Biting and Noxious Insects other than Mosquitoes

In the First Report of these laboratories it was mentioned that enquiries had been set on foot about biting flies in the Bahr-El-Ghazal province. This yielded very little in the way of specimens though Captain Brakenridge sent some useful notes about *Glossina morsitans (vide infra)*. Recently the matter was taken up more strongly when Colonel Hunter requested me to draw up a form of enquiry to be sent to Governors of Provinces and Mamurs all over the Sudan. Too elaborate a series of questions would have been a mistake and the following simple queries were eventually adopted and distributed together with specimens of *Glossina palpalis* kindly furnished by Captain Greig.

Enquiries as to biting flies

Form of Memorandum

1. Are there any flies of this sort in your district which are known to bite man?
2. Are there any flies of this sort in your district which are known to bite animals?
3. Do biting flies of any kind exist in your district?
4. If you find that any biting fly exists please state:—
   - *(a)* At what time of year it is most prevalent.
   - *(b)* In what kind of country it is found, *i.e.*, in forest land, bush country, near water, etc.
   - *(c)* If the natives in your district attribute any illness to its bite.
   - *(d)* If it bites only through the day, or only at night, or both during day and night.
   - *(e)* If it is known to attack wild game.
   - *(f)* If anything is known about its breeding habits.
   - *(g)* If it is numerous or otherwise.

A request was also made for specimens, and directions given as to how they should be sent to the laboratories.

This memorandum has been productive of good results. Flies have been sent from various parts, we have learned their Arabic names and discovered several interesting points as regards time of prevalence, distribution, etc. One amusing statement, not wholly uninstructive, was made by a certain official on the Upper White Nile, who on receipt of the notice replied, "What I am looking for is a species of fly which does not bite. Could I obtain a male and female of such a species I would start immediate breeding operations."

Results obtained

The Tsetse Fly

Pride of place may be given to the tsetse fly, of which, as already mentioned, two forms have now been found to exist in the Sudan, *i.e.*, *Glossina morsitans* (Plate I.), the carrier of trypanosomiasis in animals, and *G. palpalis* (Plate II.), the agent in the transference of the human trypanosome, believed to be the cause of Sleeping Sickness *(vide infra)*.

The most interesting fact elicited about *G. morsitans* was supplied by Major Morant, who found it in Southern Kordofan, sent specimens to the laboratories, and whose note upon it is as follows:

"The Umbogani bogey seems to be exaggerated by the Arabs, by whom it is naturally very much feared. In the time of the old Government this fly, which appears to be a species of tsetse, infested all the Koalib Hill and extended to Umberembeita. Early in the Mahdia they are said to have died off completely, and the district was exempt from them until three, or some say, four years ago when they seem to have reappeared at Jebel Ambri, which,

A tsetse fly in Kordofan

however, they are now said to have left, and to have gradually spread northwards, until, this year, they have reached Jebel Daheir, though in small numbers. It is thought they go to Umberembeita, but no further. When tribute is under discussion they are said to have killed quantities of cattle, sheep, goats, pigs, and dogs, specially when they first reappeared. However, now they seem less numerous, and the Nubas are not much afraid of them. At Daheir I was told there were very few there, whilst at Nying-Nying I was told exactly the reverse, and specimens were difficult to procure. They haunt the rocks and angal hedges near the villages, but animals can graze a mile or two away from them by day and be brought in after nightfall with immunity. The fly is present throughout the year. The fly belt extends from a place called Kawalib to about twenty miles south, and is only three or four miles in breadth. Outside the belt no flies are to be found, and there is no evidence as to their existence in adjoining districts. If asked for, natives went to the villages for them, and either found them in hedges, or on pigs, or amongst the rocks. The wells are usually situated half-a-mile from the villages."

Replying to a query, Major Morant said there were no streams or marshes in the district, the only water to be found in the neighbourhood being that in the wells.

On studying the map one found the region to be a short distance to the south of the 12th parallel of north latitude, and nearly midway between the 30th and 31st degrees of east longitude, being just about 150 miles west of Renk on the White Nile and nearly due south of El Obeid, the capital of Kordofan.

Hitherto the fly has not been known to extend north of the Bahr-El-Arab, which divides Kordofan from the Bahr-El-Ghazal province, so that this constitutes its most northerly record for the Anglo-Egyptian Sudan, and, with the possible exception of Bathurst and Lake Chad, for the African Continent as well. It is interesting to find that the name Umbogani is also that under which it is known in the Bahr-El-Ghazal. Captain Brakenbridge in the note to which reference has been made, informed me that the native name is Mboogena, the accent on the oo, which is rather short like oo in good ; the g is soft. The Golo name is Ngissa, the M'Bari name is Mbili and the Dinka name is Mow. Only the last of these names is given in Austen's Monograph where it is spelt Mau.*

Distribution of G. morsitans

From data supplied by Dr. Neave, Major Bray, Major Rivers, Captain Percival and others, I have been able to mark on the accompanying map the distribution of *G. morsitans* in the Bahr-El-Ghazal province so far as it is at present known. In some places it is very numerous and it causes great loss amongst mules and donkeys. A point to which all the observers have directed notice is that the leading men and animals of a caravan are those liable to be attacked. Those in the rear escape. The fact seems worth mentioning as the more valuable animals may gain some protection from the position in which they are placed, Major Bray and Mr. Thomas record that the fly bites during the night. Bradshaw, Selous and Crawshay, quoted by Austen, all refer to the tsetse sometimes feeding during the dark hours.

Presence of G. palpalis

It is only recently that *Glossina palpalis* has been proved to exist in Sudan territory. Monsieur Lemaire, of the Belgian scientific expedition, informed me that it existed at Wandi in the Lado Enclave and at Mvolo in the Sudan, but it was not until Major Bray sent a fly, with the following note, that this statement was definitely confirmed, for the fly on examination, proved to be a *palpalis*.

* Austen. Monograph of the Tsetse Flies, 1903, p. 299.

PLATE I

A. J. E. Terzi

Glossina morsitans, Westw. ♀ (× 6)

Found in the Bahr-El-Ghazal Province, Southern Kordofan, and on the Baro River in territory leased from Abyssinia.

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Major Bray stated, "I forward . . . a fly which I believe to be *G. palpalis*. I caught it at thirty miles post, Meridi, Mvolo road, in May. I have compared it with the two specimens kept in the Mudir's office, and have no doubt of its identity. I did not see any more, but at that time was very busy and it did not occur to me that it was *palpâlis*, and I did not look for more. At Tembura, in February, I met an intelligent Arab, one Ibrahim Ibn Sayd El Nur, from Taweisha, in Kordofan, who had come from Zemios (Zemios is about fifteen days south south-west of Temburas). He said, in reply to questions, that there was much sleeping sickness in Zemios, and that it was brought by the Belgians. The disease is accompanied by enlarged cervical glands. It has been there three years. I did not hear anything about it anywhere else."

This information is of grave significance, and no doubt Major Dansey Browning's expedition will serve to show the extent to which the disease exists, and if it has really invaded the Sudan. He may also be able to map out the fly belts and determine if *G. palpalis* exists in large numbers. Since this was written Major Browning has not only proved that *morsitans* is numerous between Wau and Chak-Chak and between Kossinger and Dem Zubeir, but he reports *palpalis* in large numbers in the district to the south-east of Mvolo and writes me to say that he has been informed from a Belgian source that *G. pallidipes* exists at Mangi. As he notes, this requires confirmation. He did not see the specimens.

I am strongly of opinion that the tsetse exists on the upper reaches of the Sobat. Mules and cattle coming from Itang and the Upper Baro districts in Abyssinia have been found suffering from trypanosomiasis. From enquiries made from members of Mr. Macmillan's expedition I find that about fifty miles south of Nasser a fly, supposed to be a large tsetse, exists. I should not be surprised if this proves to be *G. longipennis* (Plate III.) A study of Mr. Austen's latest map shows that this species might very well extend thus far west from Somaliland and north from Lake Rudolf. I hope this question may be definitely settled before the end of 1906. (Since this was written Mr. Thomas has brought in two specimens of tsetse taken by Captain C. Sullivan on the Baro in Abyssinian territory between Gore and Gambela, *i.e.*, about the intersection of the 35th degree of east longitude and a parallel of north latitude corresponding to 8° 25′. Though they are somewhat damaged I have little doubt these flies are *G. morsitans*. They are certainly not *longipennis* and answer to *morsitans* very closely though their abdominal markings are, I think, rather brighter than usual.)

G. morsitans in Abyssinia

There is no evidence which would lead one to suppose that the tsetse exists on the Upper Blue Nile. There are records of animals dying from fly bite, but other genera are implicated so far as can be told, not *Glossina*.

Several species of seroot fly have been sent both from the Blue and White Niles. Colonel Penton brought a valuable collection of *Tabanidæ* from the Jur River. Colonel Hunter presented several large biting Diptera which he had taken on the Upper White Nile, Major Bray was the donor of a good collection which he made in the Bahr-El-Ghazal and some from Captain Ensor also reached us from the same province. Captain Grogan sent flies and admirable notes from Goz-Abu-Guma and specimens have also been forwarded from Roseires and the Rahad. Captain Hughes brought a fine specimen of one of the *Asilidæ* or robber-flies from El Obeid. It is very apt to be mistaken for a biting dipteron.

Fortunately it has been possible to have these flies well illustrated in colour or in black and white. The object has been both to make complete scientific drawings and to

produce correct illustrations whereby those flies can be readily identified by anyone who secures them. For this purpose the natural colours are indicated in the black and white drawings. I believe they will be helpful in this direction and of considerable value to Medical Officers and Inspectors. Some non-biting Diptera which might easily be confounded with harmful varieties have also been illustrated. In this connection I have to acknowledge the kindness and courtesy of the Trustees of the British Museum with reference to the permission granted for the reproduction of the coloured plates of *G. morsitans*, *G. palpalis* and *G. longipennis*. Both in the identification of specimens and the criticism of the drawings we have received the valuable help of Mr. Austen, Dipterologist to the British Museum, who has also contributed a paper on some of these Diptera written specially for this report.

Notes and Specimens

Tabanidæ

Seroot is a name applied to several of the larger *Tabanidæ* found in the Sudan, such as *T. dorsivitta*, *T. africanus*, *T. socius*, *and T. biguttatus*. Other Arabic names, kindly translated for me by Sir R. von Slatin, are given to these. Thus at Goz-Abu-Guma on the White Nile, *T. dorsivitta* is called *Ter-El-Gefar* ("bird of the desert"), while *T. socius*, or a fly very like it, is known as *El Agheibish* ("the grey one").

Captain Grogan sent the following note from the Mamur of Goz-Abu-Guma regarding these flies in answer to the memorandum. They seem well worth reproducing in extenso.

1. "They bite both man and beast.

2. They appear for the most part in the time of the Kharif (May and June) and when the dura crops ripen.

3. They are found in thickets, woods and undergrowth near the river, also in the wooded parts of the interior rain lands.

4. From the effect of their bites animals lose condition and become very lean.

5. They bite during the day-time.

6. They also bite wild animals such as the lion.

7. Nothing definite is known about their breeding habits but they are said to be the same as the locust.

8. They are numerous and especially towards the south.

In addition reliable information points to the *Agheibish* being much the worst. Their favourite places for attacking animals are in the hairless part under the neck, the bare parts of the belly, and in the groin of the leg. Animals if exposed to their attacks, which draw blood, get no peace and eventually die. There is no doubt that they drive wild animals from Jebelein northwards during the Kharif." Captain Grogan further says:—"There is also to be found, to my own personal knowledge, a little way south of Goz-Abu-Guma, near to the river, during the months of April and May a third sort of biting fly, small and black, something like a house fly which attacks camels and instantly draws blood. Its name is said to be *El Agusa* ('the old one')."

Stomoxys

Specimens were afterwards sent, and, as expected, this fly proved to be a species of *Stomoxys* which I had found very prevalent at Taufikia in January, fiercely attacking mules and drawing scarlet beads at every thrust.

It is also common in the Bahr-El-Ghazal and up the Blue Nile. I do not think it can be a carrier of trypanosomes in the Sudan, otherwise many animals would have become infected at Taufikia. As a matter of fact I only found trypanosomes in mules coming from Abyssinia. Captain Greig's experiments go to prove it innocent in Uganda.*

* Greig. Reports of the Sleeping Sickness Commission of the Royal Society. No. VI., 1905, p. 203.

PLATE II

A. J. E. Trelease

Glossina palpalis, Rob. Desv. ♂ (× 6)

Found in the southern part of the Bahr-El-Ghazal Province and in the Lado Enclave.

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A new species of the vicious and mottled-winged *Hæmatopota* was brought from the Bahr-El-Ghazal by Major Bray, while a different variety has been forwarded from the Rahad. This leads us to speak of flies from the Blue Nile. These have been sent by the Mamurs of Rufaa and Roseires through Mr. Corbyn. Hæmatopota

The most interesting are the *Pangonia*, species *P. magrettii*, Fig. 12, from Rufaa, called in Arabic, *Ter-El-Bagger* ("the cow-bird") or *Dibban-El-Gefar* ("fly of the desert"). These flies, in which the proboscis is of great length, are said to be a cause of camel sickness and the reason for the migrations of camel-breeding Arabs. *Seroots* were also sent from Rufaa together with a note that they were worse during the Kharif, and bite all animals, including man. A quaint sentence may be quoted, as it is very typical of the drawbacks to work in the Sudan : Pangonia flies

"I regret I could not get them alive, because the way of catching is by beating them with a cloth or with a bundle of sticks." No wonder it is, at times, difficult to identify specimens! Yet one would rather have the interest displayed by this forcible collector than the indifference which is sometimes shown.

The notes from Roseires are somewhat confused, several species being sent together under the same heading. The Blue Nile *Hæmatopota* seem to be called *El Takasha* ("the attacking fly"), and are credited with causing "swelling of the lungs" in sheep and goats. They are said to appear in August, prevail a short time during the Kharif, and then die. *Abu Rababa* ("father of a stringed musical instrument") is the name after Austen, applied without distinction to the larger Tabanidae, while *Sartieh* seems also to be an Arabic term for Seroots.*

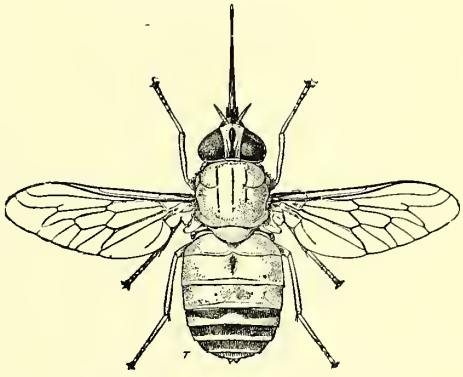

Fig. 12.—Pangonia Magretti, Bezzi ♀ (x 2)
After Austen
Egyptian Sudan, Somaliland, E. Africa Protectorate
Head yellowish; thorax yellowish brown; basal portion of abdomen ochraceous; bands on black apical portion whitish yellow; femora brown, remaining portion of legs yellow; wings suffused with light yellowish brown.
By kind permission of Trustees of British Museum.

Stomoxys were sent from Roseires, where they are called *El Naghuza*. The note, which is quite correct, states: "This fly chiefly bites donkeys, horses and mules. It bites in the legs, causing pimples which do not cause death. It appears in August."

General remarks on all the flies sent follow, which, as they show that interest is being taken, and exhibit certain peculiarities in translation, are perhaps worth recording:

1. The above-mentioned flies generally live during the Kharif, but they much prevail in July and August. They are confined to the woods and places where grass grows.
2. The natives are bited (*sic*) by all the different kinds of this fly, but are not injured The bite does nothing more than bursting blood from the spot only.
3. These flies bite by day only.
4. They bite the fierce animals to death.
5. No person appears to know anything about their breeding habits.

On the whole this information is far from being incorrect, and shows that considerable trouble has been taken to answer the questions as fully as possible.

In the First Report I stated that sand flies and owl midges were common in Khartoum. Further experience has shown that the former, the true *Simulidae*, are rarely, if ever, encountered. Small hairy flies of the family *Psychodidae*, genus *Phlebotomus* (Figs. 13 and 14), Phlebotomus Owl midges

* The word *Um-Ta-âna* ("mother of sting") is also used for certain biting flies.

are the true pests, and are often very annoying at night. By sleeping on the roof one usually entirely avoids them, but they haunt verandahs and bed-rooms, especially where there are gardens in close proximity. They probably breed amongst decaying vegetation. The

Ceratopogon

genus *Ceratopogon* containing biting flies of the midge family (*Chironomidæ*) is also represented and these insects are apt to be confused with the owl-midges above-mentioned, as those which breed on land have hairy wings. I have often heard the sharp, short, mosquito-like ping which they are said to emit when settling and recently have secured specimens.

Simulidae
Sand flies

True sand flies, the *Simulidae*, are, however, not lacking in the Sudan. The first I saw was sent by Colonel Talbot from Abu Hamed, where at times it is a veritable terror. It is

The "Kunteb"

known as the "Kunteb" and bites fiercely, though, fortunately, not during the night. It

Fig. 13.—Owl Midge (x 12 diam.)

Fig. 14.—Owl Midge.
Khartoum.
Stomach gorged with blood.

will follow its unfortunate victim several miles back from the river and renders out-door work impossible. The species has been identified by Mr. Austen as *S. damnosum*, Theob. p. 52.

The "Nimetta"

Another species is the well-known *Nimetta* or *Nemetti* of Dongola, concerning which the following notes have reached me from the Mudir of Berber:—

"It occurs in January, February, March and April. It extends from Salamanieh, north of Berya, to the Berti boundary of the Dongola Province on the river. It lives near the river and is not found at a greater distance from it than half a mile. It bites from sunrise to sunset, attacking any part of man or beast unprotected by hair or clothes. Human beings are chiefly bitten on the face and hands, animals in the region of the pudenda. Its breeding habits are unknown. It is most virulent between the extreme cold of the winter and the great heat of the summer. The hot weather kills these flies off in thousands, and finally extinguishes them. On very cold days they are not aggressive." Its habits, therefore, appear to be much the same as those of *S. columbaschensis*, the annoying "Kolumbatz fly" of Hungary.*

A large number of these flies were sent me, but they had been placed in a bottle with

* Braun. Animal Parasites of Man, 3rd Ed., 1906, p. 432.

PLATE III

A. J. E. Terzi

Glossina longipennis, Corti. ♀ (× 6)

Found in Somaliland and the East Africa Protectorate: possibly occurs near the head-waters of the Sobat River.

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loose cotton wool, and were terribly shrunken and damaged. They presented all the characteristics of a minute sand fly—the rounded shape, humped back and typical wing venation. Some of the least damaged were sent to Mr. Austen at the British Museum, who informs me that the fly is *S. griseicollis*, Becker, which was originally described from specimens taken at Assuan. (*See also* p. 52).

Pycnosoma

The green metallic *Pycnosoma putorium* is found in the Southern Sudan. Colonel Hunter brought specimens from Shambe. These flies are filth carriers, like some of the *Muscidæ* which, of course, are represented and are very numerous in certain places. *Musca domestica* is not often a great nuisance in Khartoum, though it is busy the moment the sun rises and often drives sleepers from the roofs. I have noticed that the hot weather in April soon kills off these common house-flies. They are most aggressive in February and March.

Congo floor maggot fly

Of greater interest is *Auchmeromyia luteola*, the fly whose larva constitutes the now well-known Congo floor maggot. This fly exists in the Bahr-El-Ghazal province, and specimens have been taken by Dr. Neave and Major Bray. The latter captured a pair in coitu. They exactly answer to the description given by Mr. Austen in the Liverpool Report of the Trypanosomiasis Expedition to the Congo, 1903—1904. Two specimens were recently sent me by Yusuf Eff. Darwish, of the Egyptian Medical Corps. He took them at Mongalla on the eastern bank of the Upper White Nile.

Specimens of the maggot have not yet reached me nor have I heard of it being reported as a nuisance or a cause of invaliding.* *Bengalia depressa* is also of importance medically (*vide* Mr. Theobald's report, p. 83).

Lipotera ibicis, a fly parasitic on the Ibex

Another interesting "find" was made by Mr. Crispin, who sent me a so-called tick from a tame Ibex at Suakin. I regarded this as a *Melophagus*, an insect, which though a true Dipteron bears no resemblance to a fly, yet is allied to the flat and leathery *Hippoboscidæ* which are so common in the Sudan and are found on horses, mules, camels and dogs. It turned out, however, to be a *Lipoptera*, a closely allied form and apparently a new species (*vide* Mr. Theobald's report).

I append a list of the Sudanese Diptera mentioned above and in Mr. Austen's special article (p. 51).

Muscidæ

Glossina

G. morsitans. Bahr-El-Ghazal, S. Kordofan and Upper Sobat (Abyssinia).

G. palpalis. Bahr-El-Ghazal. Lado Enclave.

G. sp.? Bahr-El-Ghazal. Southern part.

Stomoxinæ

Stomoxys sp? Upper Blue and White Niles.

Musca

M. domestica and allied sp. General.

Lucilia, *Compsomyia* } Not yet identified but probably numerous and general in distribution.

Pycnosoma

P. putorium. Upper White Nile.

P. marginale. Bahr-El-Ghazal.

* Quite recently Major Dansey Browning has sent me numerous specimens of the maggot from the Bahr-El-Ghazal province.

Auchmeromyia

A. luteola. Bahr-El-Ghazal. Upper White Nile.

Tabanidæ

Chrysops

Chrysops distinctipennis. Bahr-El-Ghazal?

Tabaninæ

Tabanus dorsivitta or virgatus (Austen)
,, biguttatus
,, socius
,, fasciatus niloticus
,, africanus
,, par
,, gratus
,, ditæniatus

Bahr-El-Ghazal and White Nile. I once caught *T. socius* in the laboratories at Khartoum. *T. virgatus* and *socius* are also found on the Blue Nile.

Hæmatopota

H. sp. nov.
H. pulchrithorax

Blue and White Niles. Bahr-El-Ghazal.

Bengalia. B. depressa—really a new genus (Austen), Bahr-El-Ghazal.

Pangoninæ

P. magrettii. Blue Nile and Kassala.

Chironomidæ

Ceratopogon ? sp. Khartoum.

Psychodidæ

Phlebotomus sp. ? Khartoum.

Simulidæ

"Kunteb," S. damnosum — Abu Hamed.
"Nimetta," S. griseicollis — Dongola.

Pupipara

Hippoboscidæ

Hippobosca equina
H. camelina
H. francilloni
H. taurina or maculata

General.

Lipoptera ibicis. Suakin.

"Bot" flies

Flies of the Family *Œstridæ*, which produce "bots" and belong to the genera *Hypoderma* and *Gastrophilus* are very common. I expect that specimens of *Ochromyia* and *Dermatobia*, whose larvæ cause myiasis in man, will yet be sent from the south. Larvæ taken from human subcutaneous tissue were sent me by Captain Cummins and identified by Mr. Theobald as those of *Bengalia depressa*.

Bengalia depressa

Non-biting diptera

Flies of less medical interest, but which might be confused with the larger biting diptera are a species of *Helophilus* (H. trivittatus), Fig. 16, the genus which produces rat-tailed aquatic larvæ in foul water collections and *Hoplistomerus serripes*, Fig. 17, one of the genus *Asilidæ* (robber-flies) sent by Captain Hughes from El Obeid. These prey on locusts. I note that *Tabanidæ* are said to be a favourite food of the fossorial wasps of the family *Bembecidæ*.* It would be interesting to know if this is the case in the Sudan. So far I

* Sharp. Cambridge Natural History. Insects, Part II., 1901, p. 482.

have never noticed wasps preying on the seroot, nor have I heard of this occurring. Information is desired regarding the larvæ of these Tabanids, and especially as to whether they are aquatic or terrestrial.

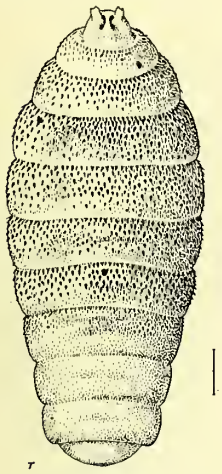

FIG. 15.—DERMATOBIA
Africana
Larva

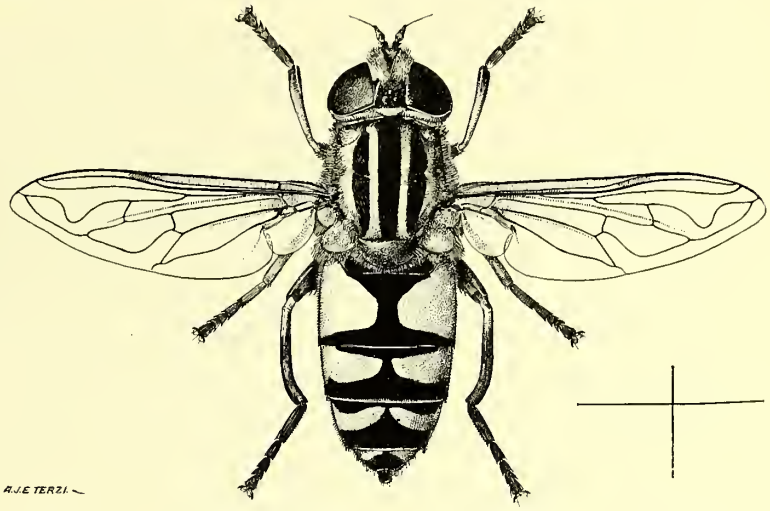

FIG. 16.—HELOPHILUS TRIVITTATUS, Fabr. ♀
Europe
Light yellow, with black markings.

The Jigger. Colonel Hunter has informed me that the Jigger or Chigoe-*Sarcopsylla penetrans* has made its unwelcome appearance in the Bahr-El-Ghazal. It is to be hoped that this crippling pest will not spread North. The Jigger

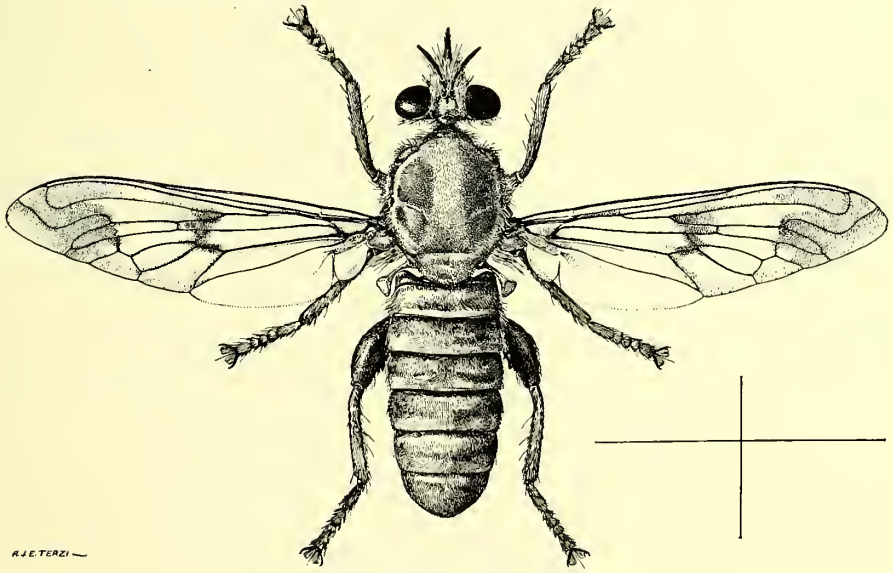

FIG. 17.—HOPLISTOMERUS SERRIPES, Fabr. ♀
S. Africa to Abyssinia and the Sudan
Black, clothed, especially on abdomen, with short, golden yellow hair; wing markings brown.

TICKS

Year by year the rôle of ticks in both human and veterinary pathology is shown to be of increasing importance. In the case of man, Spirillum Fever, the Spotted Fever of the Rocky Mountains, the Karapatti disease of the Zambesi and a fever prevalent in Persia and Beluchistan, have all been attributed to parasites transmitted by ticks. In all Ticks

probability Blackwater Fever is also a human piroplasmosis, while evidence is now accumulating to show that the rat tick and not the rat flea, may be the agent in spreading plague.

Amongst the lower animals we find Texas or Red-water Fever, Rhodesian Fever or African Coast Sickness and Trans-Caucasian Fever in cattle, to be due to ticks acting as agents of transmission. So is the disease known as Heart-water, in calves, sheep and goats, so is "Yellows," the Malignant Jaundice of dogs, so is Biliary Fever in horses, and so is the fatal Spirillosus of fowls found in Brazil and the Argentine.

Indeed, the more these *Arachnidæ* are studied, the greater seems the reason for dreading them. It is by no means an easy matter to identify ticks, chiefly because, so far, no complete and reliable work of reference to them is obtainable. The literature, though fairly extensive, is scattered, and is in a somewhat chaotic condition. Had it not been for the valuable help rendered by Mrs. Broun, I would have had difficulty in preparing even the small list of Sudanese ticks here given.

The three commonest in the Sudan are :—

Hyalomma ægyptium, found chiefly on cattle, camels, mules and donkeys.

Amblyomma variegatum, closely allied to the Bont tick (*A. hebræum*) of South Africa, the male of which has a gorgeously adorned scutum or shield picked out in golden bronze bordered with green. It is common in the southern grass country and affects cattle, camels and several species of horned game. I have taken it in Khartoum on cattle with trypanosomiasis which came from the south.

Rhipicephalus sanguineus, the dog tick par excellence, but which also attacks man, the lion, the buffalo, the roan antelope, the porcupine, and probably many other animals.

Rhipicephalus punctatissimus has also been found on the ox, and *R. Evertsi*, the Red Tick, on mules.

Mrs. Broun also recognised the spinose nymph of the ear tick, *Ornithodorus Megnini*, while I found that fowls in Khartoum were very liable to be infected with one of the *Argasidæ*, which I believe to be *Argas miniatus*. As regards the minute red ticks which I found on *Mansonia uniformis* and *Myzorhynchus paludis* on the White Nile I see that Hodges had previously described a similar infestation of these very mosquitoes in Uganda,* while the whole subject of the parasites of the Culicidæ has been fully dealt with in an interesting paper by Dr. Léon Dyé.†

The trouble about ticks is that the same species are sent in again and again, and it is difficult to get new varieties. The unskilled collector naturally mistakes the different stages in development for differences in species.

Piroplasmosis in Cattle

As regards diseases conveyed by ticks, I have never seen a case of human tick fever, nor has *Ornithodorus moubata*, the tick said to be implicated in its spread, been sent me, but I am inclined to think that the disease must exist in the Bahr-El-Ghazal Province. Quite recently I have found piroplasmata in the blood of cattle sent me from Berber by Captain Head, of the Veterinary Department. I have not had time to study the parasite fully, but its appearance is shown in Fig. 18. It is very minute and occurs in coccoid, small ring, and somewhat flame-shaped forms, while as seen in the photomicrograph dividing (spore forms) are present. No extra-corpuscular forms were seen. It is possible that the disease was introduced from Egypt, and I am not certain but that the parasite is a new one. As stated, it is very small, and yet it does not answer to *P. parvum*. At present this brief

* Hodges. Jour. of Tropical Medicine, 1902, Vol. IV., p. 293. † Archives de Parasitologie, 1904, Vol. IX., p. 1.

mention must suffice. Ticks sent from Berber proved to be *Hyalomma ægyptium* Malignant jaundice of dogs occurs, and is probably due indirectly to *Rhipicephalus sanguineus*.

I have examined female ticks taken, gorged with blood, from cattle with trypanosomiasis, but I have never found trypanosomes in these ticks. The parasites were, however, far from numerous in the cattle blood. In blood from mites taken from infected rats I have found trypanosomes alive 26 hours after the insects were removed from their host. The recent work of Skinner* has drawn attention to the possible association of *Hyalomma ægyptium* and plague. He has indicated that there is a good deal in common between the distribution of this tick and that of endemic plague (Brit. Med. Jour., 26/8/05, 16/9/05, 14/10/05). Whether or not his surmises prove to be correct, it is important to note here that both *H. ægyptium* and rats are very numerous in and about Khartoum.

Fig. 18.—Piroplasmata in Blood of Cattle, x 1375 diam.

Chicken meat in Khartoum is often very tough and unsavoury. I believe this to be due in some measure to the unfortunate birds being drained of their juices by the loathsome Argas ticks which cling to them in dozens. Some remedy might be found by oil-dressing the fowls. or by the erection of tick-proof houses in the market. The pests, however, are not greatly in evidence, and funds are required for more important matters.

Insects and Vegetable Parasites Injurious to Plants

Aphidæ

Once more one has to record the ravages of *Aphis sorghi*, the "Asal" fly of the Arabs. It caused great destruction amongst the dura crop on the Rahad, and has been busy up the Blue Nile and elsewhere. A small quantity of standing dura became infected in the Gordon College garden in October, 1905. The crop was promptly cut down and the plants burned. This prevented any spread of the disease. An application for £E50 was made to enable experiments to be carried out with lady-bird beetles. It was intended to introduce *Leis conformis* from Tasmania and *Hippodamia convergens* from California. The expenditure was not sanctioned, and perhaps it was just as well, for if such experiments are to meet with success and be carried to a conclusion they must be conducted with great care, and would require the services of an Economic Entomologist. I think I cannot do better than quote some interesting notes by Mr. Lounsbury, Government Entomologist at Cape Town, on a subject which is peculiarly his own. He says† :—

The Asal Fly

"Lady-birds, syrphus flies, aphis lions, and wasp parasites of one kind or another, prey

* Brit. Med. Jour., 26/8/05, 16/9/05, 14/10/05, 2/12/05.

† Report of Government Entomologist, Cape of Good Hope, 1900, p. 27.

on all the different species (of aphis) and some of them, at least, have fungus diseases as well to contend against. Natural checks of other kinds are still more potent in off-setting their marvellous reproductive powers; thus, myriads perish on the citrus trees with the hardening of the young wood, and violent rains dash other myriads to the ground, never to regain their food plants. The most conspicuous, as well as the most important in many cases, of the insect enemies are the lady-birds. But no species of lady-bird can increase in numbers to compare with an aphis. Few lady-birds have more than three or four generations a year in even warm climates whilst aphides are often grandparents before their first month of existence is finished. Thus it comes about that when conditions favour the increase of an aphis and it has even a short start of a lady-bird enemy, the plant infested may be severely injured before the aphis is suppressed. To cite a common example: A species of aphis *(Nectarophara pisi)* sometimes finds our sweet-pea plants early in the spring, and, say, for a week has undisturbed possession. Then the infestation is discovered by a wandering lady-bird on the search for just such an occurrence, and she at once proceeds to avail herself of it, feeding voraciously herself and laying eggs that her progeny may share the feast. The eggs hatch in about a week and then a swarm of hungry larvæ slay the helpless lice right and left. Doing their best, however, and aided by other lady-birds which have been attracted to the scene, they cannot even dispose of the increase. In a few weeks the larvæ turn to pupæ and then to adults. A second generation of larvæ is shortly produced and then the aphis is quickly overcome. Sometimes, of course, the aphis is overcome more speedily and sometimes less so; from the beginning almost there was no doubt as to ultimate suppression. The lady-bird larvæ wander about when their food supply is exhausted, but not having wings they do not get very far; some eventually find food and live to propagate, but the vast majority die of starvation or fall victims to their cannabalistic brothers or to other foes. For weeks at a time there may be practically no aphis of any kind in the locality and then the lady-birds become fewer and fewer, so that when aphides begin to appear again there are very few lady-birds about to find them. Other enemies of the aphis kind suffer similarly. These facts render it somewhat doubtful that the injuries to plants from aphides in general could be much lessened by importing new species of lady-birds since the new-comers would suffer from the same disabilities as our native kinds. Still, it is possible that the conditions might be somewhat bettered if the imported species propagated more rapidly than the natives, if they started to feed a few days earlier in the spring, or kept at work through our mild winters when there was food; likewise if they had a wider range of foods that would enable a greater proportion of them to live through their famine periods, or if they possessed greater vitality that would assist in carrying them through."

These interesting notes present the somewhat complex problems which have to be faced when tackling the question of aphis destruction in a practical manner. Moreover, it requires care and skill to rear captive lady-birds and it is difficult to feed them. They are liable to bacterial infection and doubtless many would perish or ever they reached the Sudan. Still, this seems the only likely way of combating the *Aphis sorghi*, and if successful, both the agriculturist and the treasury would greatly benefit.

In this connection I may record the discovery of a third species of predatory lady-bird which is described by Mr. Theobald (p. 93).

The only real effort to cope with the aphis in the Sudan appears to have been made by Mr. Corbyn on the Blue Nile. He employed petroleum washes at an early stage of infestation and apparently with great success, as he states that the dura crop on the Government farm

was saved. It is probable the mere vigorous washing was the effective agent in clearing off the aphides. Petroleum itself is said to have no effect on them.

New Aphides

I have found, and sent to Mr. Theobald, certain other aphides which were present on the bamboo in the south, and on diseased melon plants forwarded from Kamlin by Major Dickinson who takes a keen interest in these matters. Both, I believe, are new species. Some communications from Major Dickinson regarding his observations on the *Aphis sorghi* are here recorded.

"I have noticed that the honey is almost invariably found on the upper side of the leaf and the insect on the under side. In the few cases where the insect is found actually in the honey on the upper side, it can always be accounted for by its having dropped off a leaf immediately above. Is it known yet what becomes of the fly from December to the time of its appearance, viz:—in September or early in October? As far as I can observe with the naked eye the first appearance of the pest is a faint covering of honey on the leaf of the plant. I have never seen any insect engaged in depositing this honey, nor have I been able to detect any insects in the honey itself, except as already mentioned, when they have apparently fallen from another leaf above. If the insect is hatched in the honey it seems that it must crawl round to the other side of the leaf while still too small to be seen with the naked eye. I have also found crowds of the fly in its crawling stage on a leaf that seemed to be perfectly dry. A great deal of this honey drips off the plants on to the ground. Is it possible that the insect may be bred in the ground from this honey and spread among the plants the following season? The head of dura which I have sent you is the kind known as *Wad Fahil*. It and two other kinds, *Amian* and *Fiki Mustchi* are said by the natives to be particularly liable to the attacks of the Asal fly and they certainly seem to be in a worse plight than some other kinds, such as *Fetarita*; though I have not come across any kind yet on irrigated land that is not affected more or less. I think that this fly is in danger of becoming a very serious pest. If it cannot be hatched out before the end of September the ravages might perhaps be lessened by making the natives sow their crops earlier than they do now." Again and later, "I am anxious to hear whether you discover any trace of the Asal fly itself on the infected cotton from Berber. I planted dura at wide intervals among the cotton on the Government farm here, and some of the cotton plants which are close to the dura stalks have the honey on their leaves, but I cannot find on any of them any trace of the fly itself. I do not think that the fly attacks the cotton plant, but if planted with dura a certain amount of the honey falls from the dura on to the cotton plant, and this perhaps may injure the plant by stopping up the pores of the leaves. I will be able to see whether it does or not later on. It does not seem that the plan of wide planting does anything towards mitigating the injury done by this pest. The dura planted among the cotton on the farm was sown along each ridge at intervals of 10 feet, and the ridges themselves are rather more than a yard apart. Yet this dura is as badly affected by the Asal fly as the closely-planted dura on the native sakias, and I have had to root up quite half of it."

About the same time as the above were written a report reached me from the Rahad stating that the kinds of dura known there as *Fetarita* and *Mugud* were infected. *Najjad* was apparently immune.

The only dura plants recognizable from these native names are *Andropogan cernuum* (*Fetarita*) which yields a white grain, and *Najjad* or *Nagodi*, which is the black and red variety. As it has been impossible to undertake much field work or to study the Aphis

properly, it is not an easy matter to answer all Major Dickinson's queries. One can, however, assert that forms are found on the honey-covered surfaces. I have discovered eggs in this situation as well as winged forms. Both these are extremely minute and might easily escape naked-eye observation. The forms found on the under-surface of the leaf are usually apterous females, and the time of year at which they are found will probably indicate whether they are parthenogenetic females or engaged in oviparous or viviparous reproduction. The life-history of Aphides is so very complex and yet of such amazing interest, and the *A. sorghi* is such an important factor in cereal cultivation in the Sudan that I here take the liberty of inserting some extracts from Insects, Part II., Cambridge Natural History, by Dr. David Sharp.

"The individual life for several generations is restricted to constant, or at any rate copious, imbibition of food, accompanied by an almost uninterrupted production of young by parthenogenetic females, the young so produced becoming rapidly (sometimes in the course of eight or ten days, but more usually in about twenty days*) themselves devoted to a similar process; so that in the comparatively short period of a few months the progeny resulting from a single individual is almost innumerable. This remarkable state of affairs is accompanied by other peculiarities of physiology, with the result that the life-histories of successive generations become very diverse, and complex cycles of series of generations differing more or less from one another are passed through, the species finally returning to bi-sexual reproduction, and thus inaugurating another cycle of generations. The surprising nature of these facts has in the last 150 years caused an immense amount of discussion, but no satisfactory light has yet been thrown on the conditions that really give rise to the exceptional phenomena. These phenomena are: (1) parthenogenesis; (2) oviparous and viviparous reproduction; (3) the production of generations of individuals in which the sexes are very unequally represented, males being frequently entirely absent; (4) the production of individuals differing as to the acquirement of wings, some remaining entirely apterous, while others go on to the winged form; (5) the production of individuals of the same sex with different sexual organs, and distinctions in the very early (but not the earliest) stage of the formation of the individual; (6) differences in the life-habits of successive generations; (7) differences in the habits of individuals of one generation, giving rise to the phenomenon of parallel series. All these phenomena may occur in the case of a single species, though in a very variable extent.

The simple form of Aphid life may be described as follows:—

Life History of Aphidæ

Eggs are laid in the autumn, and hatch in the spring, giving rise to females of an imperfect character having no wings; these produce living young parthenogenetically, and this process may be repeated for a few or for many generations, and there may be in these generations a greater or less number of winged individuals, and perhaps a few males. (There is some doubt on this point, as the earlier observers seem to have supposed that a winged individual appearing in a generation chiefly apterous was *ipso facto*, a male; it seems, however, to be certain that perfect winged males appear in some species in generations producing no perfect sexual females. Speaking generally, the course of events seems to be that in summer there exist only wingless and winged parthenogenetic females, and that the sexually perfect forms appear for the first time in autumn.) After a time when temperature

*This applies to what occurs in a temperate climate. Under tropical conditions production is probably much more rapid (*vide p.* 40) Mr. Lounsbury's remarks.—A.B.

falls, or when the supply of food is less in quantity, or after a period of deliberate abstention from food, sexual individuals are produced and fertilized eggs are laid which hatch in the spring, and the phenomena are repeated. In other cases these phenomena are added to or rendered more complicated by the intercalated parthenogenetic generations exhibiting well-marked metamorphosis, of kinds such as occur in apterous or in winged insects; while again the habits of successive generations may differ greatly, the individuals of some generations dwelling in galls, while those of other generations live underground on roots.

As regards the physiology of production of winged and wingless individuals there has been but little exact inquiry. Vast numbers of individuals may be produced without any winged forms occurring, while on the other hand these latter are occasionally so abundant as to float about in swarms that darken the air; the two forms are probably, however, determined by the supply of food. The winged forms are less prolific than the apterous forms; and Forbes has noticed in *Aphis maidi-radicis*, where the generations consist partly of apterous, and partly of winged individuals, that when the corn begins to flag in consequence of the attacks of the Aphis, then the proportion of winged individuals becomes large. The appearance of winged individuals is frequently accompanied by a peculiar change of habit; the winged individuals migrating to another plant, which in many cases is of a totally different botanical nature from that on which the apterous broods were reared; for instance, *Aphis mali*, after producing several apterous generations on apple, gives rise to winged individuals that migrate to the stems of corn or grass, and feeding thereon commence another cycle of generations. On the whole, it would appear that the appearance of winged forms is a concomitant of decreasing nutrition. It is a very remarkable fact that the sexually perfect females are invariably apterous, and this is frequently also the case with the males. It is also highly remarkable that the sexually perfect individuals are of comparatively small size. There are at least three kinds of males in Aphidæ:—1, winged males; 2, wingless males with mouth well developed; 3, wingless small males with mouth absent.

We have already alluded to the fact that the mode of reproduction of Aphids leads to an unrivalled increase. This, however, is not due to the prolificness of the individual, which, in point of fact, appears to be considerably below the average in insects, but rather to the rapidity with which the young begin to reproduce. This has been discussed by Huxley, Buckton and others. The first-named naturalist calculated that the produce of a single Aphis would, in the course of ten generations, supposing all the individuals to survive, "contain more ponderable substance than five hundred millions of stout men; that is, more than the whole population of China." It has since been contended that Professor Huxley's calculation was much below the mark. Although it is somewhat difficult to make a calculation dealing adequately with the actual facts, yet it is clear that the increase of Aphids is such that, drawing as they do their nutriment directly from the plant in its growing state, in the course of two or three years there would be no nutriment available for other animals, except such as might be derived from plants not attacked by Aphids. The numbers of Aphidæ would be so great that they could not be expressed by ordinary numerical methods, and their increase would be actually limited only by the relations existing between different kinds of plants and between plants and Aphids. This result is avoided by the fact that Aphids are themselves the victims of a whole army of insect enemies. They have the numerous members of a special group (*Braconidæ*, *Aphidiides*) of minute *Hymenoptera* to live inside their bodies, and many *Aculeate* *Hymenoptera* depend entirely on the Aphidæ as the source of food for their own progeny. Enemies of the Aphis

The Lady-birds—*Coccinellidæ*—live on Aphids and Coccids, and themselves increase to such an extent as to be in many years a conspicuous part of the insect world. Crowds of the larvæ of *Hemerobiids* and *Syrphids* are constantly engaged in spearing and sucking the Aphides. Hence the old naturalist Bonnet said that, "just as we sow grain for our benefit, Nature has sown Aphids for the benefit of multitudes of different insects." He might have added that these different insects are for the benefit of man, it being clear that without them the population of the world must rapidly decrease." A short and simpler account given by Theobald* may also be quoted. He says: "They" (the Aphidæ) "live entirely upon the sap of plants, which they draw from the leaves, stem, and even roots." After mentioning the "cornicles" or "honey-tubes" and the waxy substance on the skin, he continues:—"Winged and wingless females occur, the males being also often winged. Parthenogenetic reproduction takes place; both oviparous and viviparous females are found in all species. The wingless forms are generally asexual, and so are the summer winged females. Ova are usually laid only in the autumn by the oviparous female after fertilization by the male. . . . The reproductive powers of these insects are enormous as well as peculiar. The wingless female, starting in the spring, produces with great rapidity living young without the agency of a male; these asexually-produced young or lice, soon grow sufficiently to start reproducing again, and so on for eight or nine generations. As a rule, a plant becomes smothered by these wingless forms; and in the summer some send out little bud-like growths from the thorax, rudimentary wings, a pupal stage, and from these active pupæ come forth winged females, which fly off to other plants. These winged females are also viviparous, and produce again asexually living young, and so on until the autumn when a third kind of female appears—the oviparous female, and also a male. After the male has fertilized the female aphis, she deposits a few eggs upon the plants, which remain over the winter. These eggs mostly hatch out in the spring. But many also hibernate as queen or mother females and commence to reproduce at once on the return of warm weather. There is often not much difference between the young (larvæ) or lice, as they are called, and the viviparous female, but larvæ, pupa, and adult may generally be distinguished by variations in colour."

In the light of these notes one must confess that very little is known about the Sudan Dura Aphis. We are acquainted with the autumnal forms, and in the spring one has found eggs and winged forms, but we do not know what happens to the insect when it leaves the Dura plants. To find out, careful field work would be required, continued over a long period. An aphis has been found on melon plants, but I believe this to be a different species. I have also found a very curious aphis on cotton, mounted specimens of which were submitted to Mr. Theobald. It is totally different from the *Aphis sorghi*. I am inclined to agree with Major Dickinson that the cotton plant is not liable to infestation by the latter.

Aphis of cotton

Another common but much less deadly enemy of the dura is a red *Hemipteron* or plant bug which attacks the grain seeds. Specimens of this pest have also been sent to Mr. Theobald (*vide* p. 95). No doubt it requires the same treatment as does *Aspongopus viduatus*, the bug of melons (*vide* First Report). Some cotton pests have come under notice, amongst them certain of the *Cercopidæ* or Frog-hoppers and a tiny beetle.

Both Mrs. Broun and myself bred out a Dipteron from certain larvæ which caused great damage to melons and were sent us by Mr. Durant. The fly could not be identified here, but specimens of larvæ, pupæ, and adult insects were sent to England, and Mr. Theobald describes it fully on p. 93.

A Melon Fly

* Agricultural Zoology, 1899, p. 237.

Locusts

This year, 1905, the question of locust destruction has come prominently into notice. Various parts of the Sudan have been visited by swarms of these destructive insects and great damage has been done in some districts—notably about Kamlin and in the Berber Mudiria. Khartoum has not been exempt, and the whole question is a very serious one for Agriculturists. One took the opportunity of the visit of Professor Werner of Vienna to the Sudan, and enlisted his kind help in the identification of such specimens of Sudan locusts as had been collected. The following have been obtained: Locusts

Acrida variabilis	Schistocerca peregrina
Acrida nasutus	Acrydium ægyptium
Pœcilocerca hieroglyphica	Acrydium succinctum
Phymateus Hildebrandti	Ærotylus patruelis

Gastrimargus, sp.?

In Khartoum the commonest species is *Pœcilocerca hieroglyphica* which haunts the Ushar plants *(Calotropis procera)* while the swarms which visit us are usually composed of the yellow *Schistocerca peregrina* or the brownish-red *Acridium ægyptium.*

I was requested to prepare some instructive notes regarding locusts and locust destruction and these are introduced in this article. They make no claim to originality save possibly as regards their arrangement, and care has been taken to include only simple and easily managed methods of prevention or destruction. The information was derived in part from the Sudan Instructions of 1901, supplied by the British Museum authorities, from French and American sources, and from various works and pamphlets on the subject.

Locust Prevention and Destruction

It is very important that correct information be obtained regarding the breeding places of locusts in the Sudan, having respect both to locality and season. It is also desired that prompt preventive and destructive measures should be taken on the appearance of these pests. Locust prevention and destruction

The following items of information are furnished. From a study of these you should be able to educate some of the natives so that they may help to furnish the required information and be led to take an interest in locating the breeding grounds and destroying the eggs and insects. Form of Memorandum

1. Locusts are:—

   (*a*) Permanent; (*b*) Migratory.

2. Swarms of locusts alight on the ground for two purposes:—

   (*a*) To lay eggs; (*b*) To feed.

3. A locust dies as soon as its eggs are laid.

4. The eggs are laid in clusters in the soil, preferably in undisturbed land and where there is bush and grass. Moist land is usually avoided but the banks of water courses constitute favourite localities.

5. With their sterns the female locusts bore holes in which the eggs are laid. These holes look rather like the pits made by rain drops.

6. The presence of holes does not necessarily mean that eggs are present. It usually means that the locusts have been disturbed when laying, as when the act is complete the holes are carefully covered.

7. The best guide to the eggs is the presence of dead locusts lying on the ground.

8. The egg clusters are usually found at a depth of two inches.

9. Flights and egg-laying may be expected after the rains.

10. Eggs, if not disturbed, are not destroyed by being covered with water. They will hatch out when the submersion is over.

11. A single egg somewhat resembles a grain of wheat in shape. The eggs in a cluster are arranged in rows with grooves between them.

12. The number of eggs laid by a well developed locust varies from 100 to 150.

13. The time of hatching varies from 15 days to several months, depending on climatic condition and soil temperature.

14. When the eggs have been laid, a few well-grown locusts are said to remain behind to guide the young ones. Information is required on this point, and also as to the length of time egg-laying lasts. In some places this is as much as 6 or 8 weeks in the same locality.

15. The young locusts are called "Hoppers." They roost at night on grass tufts, bushes, boughs, etc., and descend to the ground before sunrise.

16. The "hopper" stage is said to last about 50 days. It terminates by the production of the adult winged insect, the "hopper" shedding a scale or shell which remains on the twig or leaf where the transformation takes place and which looks very like a live locust.

17. Locusts only migrate on account of insufficiency of food.

Destruction

The means to be employed may be classed under five divisions:—

(*a*) Encouragement of natural agencies.
(*b*) Destruction of the eggs.
(*c*) Destruction of the young or unfledged locusts.
(*d*) Destruction of the mature or winged insects.
(*e*) Preventive measures.

(*a*) *Encouragement of Natural Agencies.*—In the Sudan all that could be done in this direction would be to protect the smaller birds. The destruction of hawks is advisable for this purpose. Fowls and turkeys are useful foes. It is worth noting that the large monitor lizards (*Warana*) feed greedily on locusts.

(*b*) *Destruction of the Eggs.*—This is usually accomplished in five ways:—

1. Harrowing.
2. Ploughing or spading.
3. Irrigation.
4. Tramping.
5. Collecting.

2. In the Sudan ploughing to a depth of 2 inches might be tried in certain localities.

3. Irrigation is only of use when the land can be flooded for a few days, just at the time when the bulk of the eggs are hatching.

4. Turning animals loose on infected land is a useful method. Cattle, horses, sheep and goats may be used in this way in any area where they can be confined in some measure.

5. Collecting is probably the best plan in a country like the Sudan. Buying eggs at 16 to 30 piastres an oke has been found very effective in Cyprus and Tunis, and might be tried. In any case it would lead to useful information being obtained from native sources.

The proper way to collect eggs, especially if the soil is light and the eggs are numerous, is to slice off about an inch of the surface by trowel or spade, remove the egg-laden earth to

a sheltered place where it can be sieved, and thus separate the eggs and egg masses from the dirt. This method is probably too elaborate for most districts, but might be tried in some.

The collected eggs are to be destroyed by burying in deep pits, taking care to have the earth packed hard on the surface.

(c) Destruction of the Young or Unfledged Locusts. This may be done by:

1. Burning.
2. Crushing.
3. Trapping.
4. Catching.
5. Use of destructive agents.

1. Burning is useful in a grass country. Where there is no cover for roosting, grass bundles may be laid down into which the locusts will gather at night. These can then be burned.

A simple burning method is to have a stout wire, say 40 feet long, enveloped in rags which are soaked in oil. A slender wire is then wound round to fix the rags in position. These are set alight, and two men drag this contrivance to and fro until the fuel is exhausted. It is not necessary to pass over the same ground more than once or twice, so that a large field of grain can be thus protected during the half-hour or so that the rags burn.

2. *Crushing.* This is only of use where the ground is smooth and hard. Short of crushing, beating with palm or other branches is useful, as the smallest injury to a locust will prevent its obtaining maturity.

3. *Trapping.* Various kinds of traps have been devised. Simple ditches and trenches are useful, 2 feet wide by 2 deep and with perpendicular sides. They have to be carefully dug to be effectual.

As regards traps, reference must be made to the Sudan Instructions of 1901. The same applies to:—

4. *Catching.* Screens and bags are described in the Instructions.

5. *Use of destructive agents.* Coal oil is very deadly to young locusts. It may be employed in conjunction with irrigating ditches. The following useful notes are quoted as being possibly applicable to some districts in the Sudan.

"The method consists essentially in pouring, or better, dropping coal tar or coal oil on the running water with which the irrigating ditches are supplied. It is only necessary to sprinkle a few drops of coal tar on the stream, when the oils contained in the tar are diffused over the surface of the water, and coming in contact with the insects, cause their speedy death. The toxic power of coal oil upon the insects is very remarkable; a single drop of it floating on the water is capable of causing the death of a large number of insects. A simple and ingenious mode of keeping up a constant supply of the tar to a ditch is as follows:—

"A three-quart can is perforated on the side close to the bottom, a chip loosely fitting the aperture is inserted therein, and the can is then immersed in the ditch. Three-quarts or less of tar, trickling out drop by drop from this slight vent, are sufficient to keep a great length of ditch supplied with coal oil for 36 hours. The precise extent of ditch which may thus be rendered toxic to the locusts cannot, of course, be exactly stated. It is in fact quite indefinite, for the reason that the quantity of oil necessary to kill one of the insects is almost infinitesimal, and for the further reason that a single drop of oil will cover quite a large surface when dropped on water, so that taking these two facts together, it is easy to see that a very small quantity of tar or oil will serve to guard, by means of ditches, a large tract of territory from the ravages of the young (unwinged) locusts." Creosote oil prepared with

soap and water is effective, but has to be used with sprayers. Poisonous arsenical preparations can scarcely be considered suitable for most parts of the Sudan.*

(*d*) *Destruction of the mature or winged insects.*—But little can be done in the case of large swarms. Catching and bagging as for the young forms are the most useful methods. Long ropes perseveringly dragged to and fro over fields have been used to good advantage.

(*e*) *Preventive measures.*—On the approach of a swarm the rules to be observed are:—

1. Every available inhabitant, man, woman and child, to be called out and divided up into bodies of 50, each body having its own place indicated beforehand.

2. Each individual member to be armed with some sort of noisy instrument (old tin petroleum cans and thick sticks are the best).

3. When the flights appear, the various bodies must spread out in line and march over the fields in open order, striking the cans. Smoke fires can also be lit, but the above system has been found more effective.

4. The flight should be signalled to neighbouring stations and districts. The Sheikhs of tribes should be instructed to report the appearance of any flights and, if possible, to mark down the spots where the locusts alighted for laying purposes. This ground should then be examined by a competent person, and watchers put over it. Rewards should be offered to natives for reports of laying grounds."

These notes seem to have helped the authorities at Kamlin where vast numbers of hoppers appeared. By a system of purchase 200 okes (5 cwt.) of hoppers were obtained within 10 days, while trenches proved effective. As pointed out by the Governor, the trouble is that fresh swarms invade the territory which has been cleared, and naturally this greatly disheartens the natives. Again I would quote Mr. Lounsbury on a very important point to which he has drawn attention in his report for the half year, ending June 30th, 1904. It is to the effect that locust eggs may possibly remain in the soil for years and then hatch out. He says:—

"That locust eggs may hatch after being in the soil for several years is a proposition that few zoologists would entertain, but I confess that I no longer think it impossible, and incline to believe there is a basis of facts to the common notion that voetgangers (hoppers) have often appeared in localities not visited by winged locusts for ten years or more. It may be that under certain conditions, the eggs on being extruded are enveloped in a substance which retards desiccation and the absorption of water by them much more than the secretion which is used to line and cap the egg-cells ordinarily made. Mr. Stewart Stockman records the deposition of eggs embedded in a firm, hard, secretion by miniature unfledged females of a species of acridium in India; these egg masses are evidently designed to resist the desiccating influence of the dry season, which season intervenes before the mature locusts deposit egg-masses of the ordinary type. If eggs of our ordinary locust do sometimes remain alive but unhatched for a period of years, it may be this feature of the creature's economy that is responsible for the sudden appearance of vast swarms. The parasitic and predacious enemies would practically disappear during the protracted sleep of the pest, and thus there would be insufficient means to prevent the development to maturity of the myriads that might hatch."

The locust fungus

As regards the use of the African locust fungus, *Empusa grylli*, I wrote Dr. Edington, Director of the Bacteriological Institute, Grahamstown, Cape Colony, asking him to kindly

* The planting of the Castor-oil Plant (*Ricinus communis*) round small fields and gardens might also have been advocated as it is poisonous to locusts.—A. B.

furnish me with his views as to its probable utility in a very hot and dry country like the Sudan. His reply was distinctly unfavourable to the fungus, and Mr. Theobald expressed a similar view. Dr. Edington, however, suggested that it might be well, if locusts were found dying in large numbers, to have their bodies sent to the laboratories where they could be examined. In this way a fungus might, perhaps, be found suitable to our climatic conditions.

Acting on this advice I informed the Civil Secretary, and notices were at once distributed. Two interesting letters have, so far, been the result, one from the Governor at Dueim, the other from Mr. Nevile, Manager of the Sudan Experimental Plantation Syndicate at Zeidab in the Berber district. Major Butler wrote, "Some time ago a great many locusts died at Shatt; the people ate them and a great many of them were made ill." An effort is being made in his district to obtain dead locusts for examination. Mr. Nevile, writing November 6th, 1905, remarks, "I am glad to say that for the time being we are practically free from these pests, though a little while ago we exterminated a considerable swarm of small ones. During the last flight, however, we noticed a considerable number of dead ones killed by the Tachina fly or the local representative of this insect, of which I forward you a couple of samples bred from the maggots in the locusts." (These proved to belong to the family *Tachinidæ sp?*) "The latter were not dead when the maggots were extracted. As, from what I read, this fly thrives in dry countries and is a considerable help in reducing the number of locusts, it may be that in time it will wipe them out. From what I hear there has not been a bad locust year since 1898 in this part of the country, and this was the last of a cycle of three or four years. Again, I understand that in this part of the country the duration of the present attack is quite unusual. In most locust years heavy flights occur for a few days, usually in March, April and May, and then disappear. This year they have remained from March to October practically continuously. The worst locust years appear to coincide in some respects with the high Niles, *e.g.*, the worst attacks here have been in 1312,* *i.e.* (1894), 1316,* high Nile years (though there were none in 1310*, 1314*), and therefore presumably rainy years. The fact that the locusts usually appear here before the rainy season would tend to show that there was no connection between the food supply in the immediate neighbourhood and their appearance. Possibly they have had a rainy season in the Abyssinian highlands the year previously. Locust swarms here always appear to come from the Kassala district and, according to local report, their visits coincide with good rains there. Here locusts never appear in the winter which natives say kills them off. On the Blue Nile, however, I think I have heard of vast swarms in December, 1900. Any information you can give me on these points will be much appreciated as they may have a direct bearing on the period for planting crops, and the frequency of their visits is a matter of vital importance to capitalists thinking of investing in landed property here."

Causes of irregularity of locust visits

One was able to give Mr. Nevile some of the information he desired, at least, as regards the irregularity of locust visits. This is said to depend on three facts:—

1. That the increase of locusts is kept in check by parasitic insects.

2. That the eggs may remain (as already noted) more than one year in the ground and yet hatch out when a favourable season occurs.

3. That the migratory instinct is only effective when great numbers of superfluous individuals are produced.

* In the Mohammedan Calendar.

I again quote Dr. Sharp, who says: "It is not known that the parasites have any power of remaining in abeyance, as the locust eggs may do, and the bird destroyers of the locust may greatly diminish in numbers during the year, when the insects are not numerous; so that a disproportion of numbers between the locusts and their destroyers may arise, and for a time the locusts may increase rapidly, while the parasites are much inferior to them in numbers. If there should come a year when very few of the locusts hatch, then the next year there will be very few parasites, and if there should then be a large hatching of locusts from eggs that have remained in abeyance, the parasites will not be present in sufficient quantity to keep the destructive insects in check; consequently the next year the increase in number of the locusts may be so great as to give rise to a swarm."

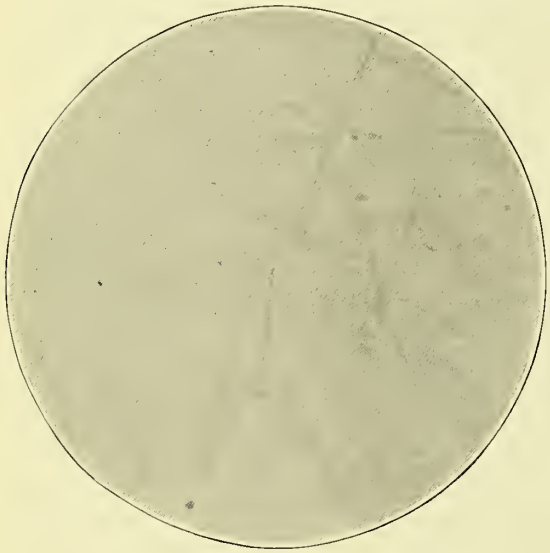

Fig. 19.—Fungus of Wheat Grain

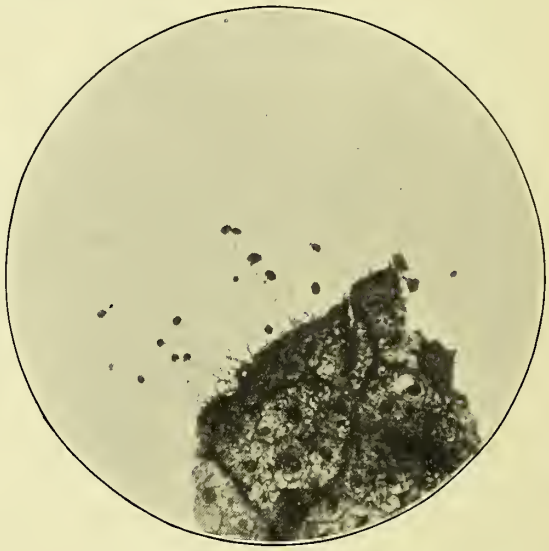

Fig. 20.—Fungus of Cotton

More recently in dead locusts sent from Suakin I have found a fungus which grows as a white culture on agar slope. It may or may not have killed these locusts, but it is proposed to test it next locust season. In locusts from Senaar a form of acarus was present.

Vegetable Parasites

Vegetable parasites of plants

Vegetable parasites of plants have not been much in evidence. Some imported wheat grains intended for planting were sent by Major Dickinson, as they had been attacked by Acari. In the holes formed by the insects I found a very beautiful little fungus of a kind quite unknown to me. The tiny spear-headed sporangia (Fig. 19) are very delicate, and nothing like them is figured in Tubuef and Smith's standard work on the subject. On old cotton plants sent from Berber black patches of a mycelial fungus with conidia and conidiophores were present (Fig. 20). It may be *Macrosporium nigricantium* Atks.

On Some Blood-Sucking and other Diptera from the Anglo-Egyptian Sudan Collected During the Year 1905, with Descriptions of New Species

BY

Ernest E. Austen

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In the following paper, which contains notes on some of the most interesting of the Blood-sucking Flies (Diptera) met with during the past year, two species and one sub-species, all of which belong to the family *Tabanidæ*, are described as new. The list of novelties might possibly have been longer, had it not been for the damaged condition of some of the specimens, which rendered determination a matter of impossibility. Those who are in a position to help to increase our knowledge of the Blood-sucking Flies of the Sudan, by collecting and forwarding specimens, should bear in mind that a little care and deftness of handling on the part of the collector may save the unfortunate systematist, whose task it will be to determine or describe the species, a good deal of trouble and eye-strain later on. In the case of many seroot-flies and other Diptera, to discriminate correctly between species is often a matter of no little difficulty even when the condition of the specimens is all that can be desired; but when precisely the opposite is the fact, when the antennæ are missing, and thorax and abdomen are more or less denuded of their natural covering, the determination of species is often impossible, and though they may in some cases be recognised as new, their description as such is out of the question. To expect the systematist to turn out satisfactory work with material of this character, is no doubt gratifying if regarded as an expression of confidence in his powers, but it is scarcely more reasonable than to require a student of tropical diseases to diagnose a case of Trypanosomiasis from a six months' old blood smear on a loin-cloth. To become a satisfactory collector of Blood-sucking and other Flies is not difficult, and pre-supposes no more delicacy of manipulation than any medical man should possess. Full directions as to procedure will gladly be sent to all those willing to assist, who will be good enough to make application to the writer of this paper.* In the meantime the following points, all of which are the outcome of practical experience, should be borne carefully in mind.

Diptera

Directions for collectors

(i.) Specimens of Blood-sucking and other Diptera intended for determination should be in the most perfect possible condition.

(ii.) Specimens collected by *natives* seldom fulfil this requirement.

(iii.) Wherever possible Flies should always be pinned, and should be drawn up *near the head of the pin*, not left close to the point.

(iv.) If pinning is impossible, specimens are best placed in three-cornered envelopes of soft paper, after the method adopted by collectors of butterflies.

* *Cf.* "Blood-sucking Flies, Ticks, &c., and How to Collect Them," by E. E. Austen. Second Edition. London: British Museum (Natural History), 1905. 22 pp., with illustrations in text.

(v.) Flies should never be placed in contact with cotton wool, since, when dry, it is impossible to disentangle them without pulling off antennæ, legs, &c.

(vi.) If specimens are placed in spirit, a plug of soft paper should always be inserted into the tube, and pressed down on to the top of them, in order to prevent the flies from being injured by washing about.

(vii.) There is no necessity to send off single specimens for determination as soon as obtained; identification will be facilitated if a series of specimens, if possible, of both sexes, be sent.

(viii.) Specimens should always be labelled with name of locality and date of capture; brief notes of interest may be added.

(ix.) *Labels should be legible.*

BLOOD-SUCKING SPECIES

Family SIMULIDÆ (Sand-Flies)

Genus SIMULIUM, Latreille

Simulium damnosum

Specimens of two species of the troublesome pests belonging to this genus were received; for notes see Dr. Balfour's Report, p. 34. The larger of these, the *Kunteb* of Abu Hamed, is

Simulium damnosum, Theob.

Reports of the Sleeping Sickness Commission, No. III. (1903), p. 40.

This species is from 3 to $3\frac{1}{2}$ mm. in length, and has the ground-colour of the legs dark brown, with the exception of the hind tarsi, where a broad band on the first joint and the extreme base of the second joint are pale yellow. *S. damnosum*, which may be distinguished from the following species by its larger size and dark legs, also occurs in Uganda, where its native name is *Mbwa*. A correspondent writing from Entebbe with reference to this species recently stated that: "Its bite is very poisonous and irritable, and causes large swellings which usually end in sores. Localities where this fly is present are very sparsely inhabited."

The second species, the *Nimetta* or *Nemetti*, of Dongola, is

Simulium griseicollis, Becker

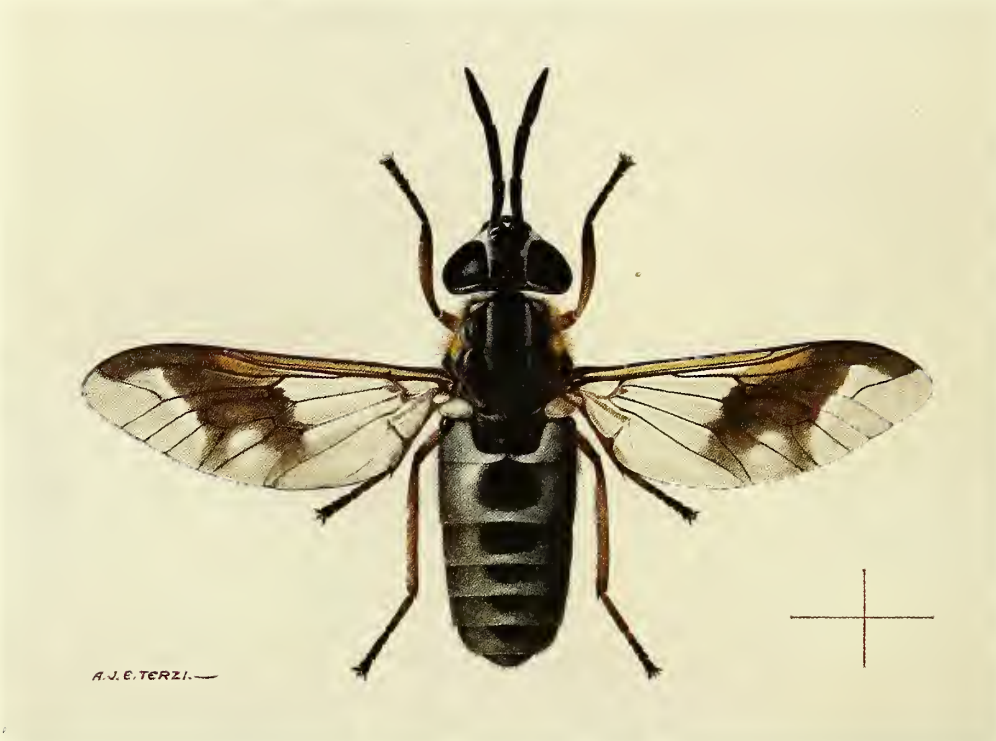
Simulium griseicollis

Mitt. aus dem Zool. Mus. in Berlin, II. Bd., 3 Heft. (1903), pp. 78-79.

S. griseicollis, the types of which were taken at Assuan in the month of February, is from $1\frac{1}{4}$ to 2 mm. in length. Since the original description of this species is not likely to be generally accessible, a translation is appended below.

"♂. Dorsum of thorax velvety black, but in front broad and grey, as also before the scutellum and on the sides, so that of the velvety black coloration there remains only a fairly large median patch; the anterior grey transverse band is interrupted by three fine black longitudinal lines, which embrace the commencements of two admedian longitudinal stripes; the grey transverse band in front of the scutellum is a little apart from the latter, and when seen from a certain direction has an almost silvery white sheen, while on the anterior part of the dorsum of the thorax no silvery white coloration is to be seen. The dorsum of the thorax is, especially on its anterior half, clothed with a coat of golden yellow, felt-like hair. Scutellum velvety black. Pleuræ ashen grey pollinose. Halteres white. On the head the face is grey; the antennæ are blackish-brown, except the first joint, which is yellow; palpi brown. Abdomen velvety black, with pale yellow margins to the segments; the second

PLATE IV



CHRYSOPS DISTINCTIPENNIS, AUSTEN ♀ (× 6)

segment on both sides with a pale grey bloom; long brassy yellow hairs on the margin of the first. Hypopygium ashen-grey. Legs pale yellow, with blackish-brown coxæ; tips of femora and tibiæ, brown; on the anterior legs this brown colour is reduced, and on the femora there is frequently only a ring or a spot on the under side. Front tarsi entirely blackish-brown; tarsi of the hinder pairs of legs from the second or third joint onwards, as also the tip of the first joint, brown. Posterior tibia and first tarsal joint somewhat expanded. There is scarcely any trace of hair on the legs, and in the same way a whiter coloration on the tibiæ is only very feebly indicated. Wings hyaline, the anterior veins pale yellow.

"♀. Thorax entirely ashen-grey, with a coat of pale brassy yellow felt-like hair on the dorsum, on the anterior portion of which three fine brown lines appear in addition, whereby are marked off two admedian grey longitudinal stripes. The abdomen, too, is entirely ashen-grey, and covered with a thick coat of pale yellow felt-like hair. In other respects there are no further differences from the male."

Family TABANIDÆ, (Seroot-Flies, &c.)

Genus Chrysops, Meigen

Chrysops distinctipennis, sp. nov.

(Plate IV.)

♀. (7 specimens), length 8½ to 10 mm.

Chrysops distinctipennis

Black; abdomen dull olive-grey, silvery-grey on basal angles, hind margins of segments silvery or yellowish, a black median blotch not reaching hind margin on each of the segments except the last: legs ochraceous, with front tarsi, tips of all femora, distal fourth to distal half of front tibiæ, and last three joints of middle and hind tarsi brown; coxæ and trochanters black; brown transverse band on wing not touching fork of third vein, and near hind margin with a semi-clear space in fourth and fifth posterior cells; stigma orange-ochraceous; costal border before it brownish.

Head: shining black, with a cinereous pollinose stripe on each side, from middle of front (space between eyes) to margin of jowl, and a similar and somewhat triangular median stripe from base of antennæ to margin of buccal cavity; on the front the lateral pollinose stripes are connected by a narrow pollinose band; antennæ moderately stout, but first joint not thicker than second.

Thorax: dorsum (in *denuded* specimens) shining black, greyish pollinose in front and with a pair of admedian longitudinal greyish pollinose stripes on anterior half; a tuft of bright golden hair below humeral callus, a similar tuft in front of base of wing, connected with a row of hair of same kind on hind margin of mesopleura.

Abdomen clothed with minute yellowish hair; dull black median blotch at base of each of first four segments broad, quadrate, diminishing in size in succession from the front.

Wings: infuscated costal border before stigma not descending below third longitudinal vein, and scarcely darker than stigma itself; prolongation of infuscated costal border beyond transverse band dark brown, sharply defined, and ending abruptly just below upper branch of third longitudinal vein; lower portion of apical half of wing slightly infuscated, leaving outer margin of brown transverse band bordered by a whitish streak (seen also in many other species), which is interrupted by a prolongation of transverse band to hind margin and so forms the semi-clear space in fourth and fifth posterior cells.

Halteres: dark brown.

Described from a ♀ from Busoga, Uganda, 1903 (*Colonel D. Bruce, C.B., R.A.M.C.*). Type in British Museum (Natural History). A single ♀ of this species, without locality label, was received last year from Dr. Balfour for determination. In addition to six specimens from Busoga (*Colonel Bruce*), the British Museum collection contains a single ♀ from Buruli, Uganda, taken in 1903 in a patch of forest on the Lukoge River, half way between Junda and Kisiliza (*S. C. Tomkins* per *Dr. Nabarro*).

Chrysops distinctipennis is closely allied to *C. stigmaticalis*, Lw., originally described from "Caffraria," of which the Museum possesses specimens from the Transvaal and Mashonaland; the differences presented by the new species are as follows:—First joint of antenna more slender, of same thickness as second joint, instead of distinctly if only slightly swollen; costal border of wing as far as stigma brownish (by transmitted light nearly same colour as stigma), instead of dark brown and continuous with transverse band, leaving stigma isolated; outer margin of dark brown transverse band on wing nearly straight, with no projection to base of fork of third vein; infuscation in basal cells confined to the tips, their bases, with exception of an extremely small and scarcely noticeable fleck in each, entirely clear.

Genus Hæmatopota, Meigen

Hæmatopota pulchrithorax, sp. nov.

(Plate V.)

♂, ♀.—♂ (2 specimens), length 11¼ to 11¾ mm., width of head 4½ mm.

♀ (15 specimens), length 9⅓ to 12 mm., width of head 3 to 3⅔ mm.

Hæmatopota pulchrithorax

Reddish-brown; thorax longitudinally marked with a broad median grey stripe, very conspicuous in undamaged examples, but in rubbed specimens largely replaced by brown; abdomen with margins of segments and narrow median stripe, greyish; tibiæ with two yellowish bands; wings brown, light markings whitish in ♂, yellowish in ♀.

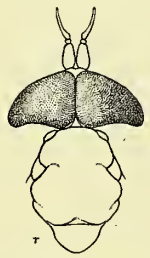


Fig. 20A. — Hæmatopota pulchrithorax (Austen). Head and Thorax of ♂

♂, ♀.—*Head:* greyish; face with a transverse brown stripe below antennæ, less conspicuous in ♂; first joint of antennæ conspicuously swollen, towards base lighter in colour and greyish pollinose.

Thorax: median stripe broader and parallel-sided from front margin until just behind transverse suture, which makes a brown notch on each side; the stripe then narrows until near hind margin, when it curves outwards on each side; each curve carries a forwardly directed tooth-like angular prominence; sides of dorsum of thorax with greyish markings; pleuræ greyish; scutellum greyish, with a rounded brown blotch on each side, usually connected with the base but sometimes isolated.

Legs: distal band on front tibiæ sometimes absent or indistinct; first joint of front tarsi usually narrowly yellowish at base; first joint of middle and hind tarsi, except tip, pale yellow.

Wings: stigma dark brown; the usual conspicuous brown patch underneath it extends unbroken into first posterior cell; discal cell largely brown, but proximal third, a transverse mark consisting of two curves at commencement of distal third, and sometimes a more or less indistinct mark beyond this pale; the pale proximal third sometimes more or less filled up with faint brownish markings; ends of both basal cells, and bases of first submarginal and first posterior cells, largely pale; in the marginal cell beyond the stigma and extending into the first sub-marginal is a squarish pale area, enclosing a rounded or elongate brownish

PLATE V

Hæmatopota pulchrithorax, Austen ♀ (× 6)

fleck; a sinuous clear mark extending from the under side of the end of the second vein, to the hind margin below the end of the main stem of the third vein, and a similar but shorter mark on the inner side of this, starting from the second vein and sometimes fused with the first mark just above the third vein, usually conspicuous; *for remaining wing-markings, see plate.*

Halteres: knob dark brown, stalk white or yellowish white.

♂.—A small brown fleck above base of antennæ; first joint of antennæ clothed with long and fine brownish hair; second joint produced above into a dark prominence; third joint, especially expanded portion, pale brown; terminal joint of palpi oval, clothed on outer side with long and fine brownish hair; upper three-fourths of eye composed of very large facets, which extend to hind margin; median portion of dorsum of thorax clothed with long and fine brownish hair, pleuræ thickly clothed with white hair.

♀.—Transverse callosity above antennæ rather narrow, shining reddish brown, uniform in width, and, in specimens in good condition, partly interrupted in median line by a yellowish pollinose depression, which is connected by a narrow dark-brown mark with the base of each antenna; uppermost of the usual three dark brown spots (arranged in a triangle) on front above transverse callosity, smaller than the other two, and sometimes indistinct; ground colour of front greyish, with a pair of brown triangular flecks on vertex, and sometimes a Y-shaped brown mark separating the dark-brown spots, and extending to the transverse callosity; basal portion of third joint of antennæ, broad; palpi buff-coloured, distal joint long and narrow, on outer side brownish, except basal fourth and extreme tip, and clothed with dark brown hair; sides of first four abdominal segments grey; dorsum of fourth and following segments (in well-preserved specimens) with a pair of rounded greyish pollinose spots at the base, one on each side of median stripe.

Described from a ♂ and ♀ from Salisbury, Mashonaland, November—December, 1899 (*G. A. K. Marshall*). Types in British Museum (Natural History).

A single ♀ specimen of this species, without label showing precise locality, was received from Dr. Balfour. The geographical range of *H. pulchrithorax*, as indicated by specimens in the Museum collection, extends from Zululand to the Sudan, and includes British Central Africa and Uganda. In the latter country, the species was met with at Fajao, on the Victoria Nile, in November, 1904, by Captain E. D. W. Greig, I.M.S.

What is perhaps a sub-species of *H. pulchrithorax* is represented in the Museum collection by a single female from the Lunyina River, Henga, British Central Africa, January 29th, 1894 (*Captain R. Crawshay*); this individual differs from the typical form in the first joint of the antennæ being more slender, and the wing-markings more confluent, especially towards the hind margin, while the space beyond the stigmatic patch on the costal border is almost clear. A closely allied species also occurs in Somaliland, and is distinguished in the female sex, as shown by a single specimen presented in 1894 (*Th. Greenfield*) by its paler front, by the greater depth of the supra-antennal transverse callosity, and of the grey hind margins to the distal abdominal segments, &c.

Hæmatopota pulchrithorax belongs to a group of species, the members of which resemble one another very closely in the pattern of the marking, both of the dorsum of the thorax and of the wings. These species differ in various respects, such as the depth and shape of the transverse supra-antennal callosity, the width of the basal portion of the third joint of the antenna, &c.; but the markings referred to are of the same type in all. The grey median thoracic stripe, most clearly exhibited by good specimens of *H. pulchrithorax* (see

plate) is much reduced in some of the species of the group, in which it is largely replaced by the brown of the ground colour, but its characteristic outline, albeit interrupted, is still distinctly traceable. The same thoracic marking is also seen in the case of *Hæmatopota decora*, Walk. (syn. *H. dorsalis*, Lw.), which ranges from Natal to Northern Nigeria, but this species, apart from its general darker colour, is distinguished at once by the pattern of the wing-markings, by the upper half of the face being entirely black, and by the marking of the front and hind tibiæ, which consists of but a single broad white band near the base. In the case also of *Hæmatopota vittata*, Lw. (Dipterenfauna Südafrika's, p. 50 [122], Tab. I., figs. 28-30, 1860), which was described from a specimen from Lake Ngami, the upper half of the face is stated to be black; this species, however, has wing-markings of the *pulchrithorax* type, and doubtless belongs to the group, in spite of Loew's somewhat misleading description and figure of the thoracic stripe.

Genus Tabanus, Linnæus

Eight species of Seroot-flies belonging to this genus are noticed below; the Sudanese form of one of them appears to constitute a new subspecies, which is here described. Specimens of certain other species received during the past year were unfortunately too much damaged to be recognisable.

Tabanus par, Walk.

(Fig. 21)

'abanus par

Tabanus par, Walker, List Dipt. Ins. in coll. Brit. Mus., Part V., Supplement I. (1854), p. 235.

Tabanus rufipes, Macquart (*nec* Meigen), Dipt. Exot. I., 1 (1838), p. 124:—*nomen bis lectum.*

Tabanus luteolus, Loew, Öfv. af K. Vet. Akad. Förh., 1857, p. 348; Dipt.-Fauna Südafr. (1860), p. [117] 45.

(N.B.—This synonymy is new.)

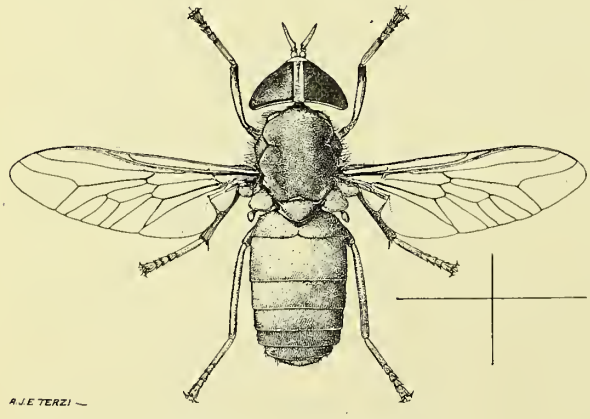


Fig. 21.—Tabanus par, Walk. ♀
Natal to the Bahr-El-Ghazal
Thorax yellowish; abdomen and legs ochraceous.

Specimens of this species, without indication of precise locality, were received during the past year from Dr. Balfour. Females of *Tabanus par*, which vary in length from $9\frac{2}{3}$ to $12\frac{2}{3}$ mm., are recognisable by their yellow colour, small size, uniformly yellow legs, and clear wings with yellow veins. The dorsum of the thorax is somewhat greyish yellow, while the abdomen is tawny or ochraceous; the third joint of the antennæ is ochraceous-rufous; the front (space between the eyes) is narrow. In life the eyes are green, without transverse bands.

The range of *Tabanus par* extends from Cape Colony and Natal to Uganda and the Bahr-El-Ghazal.

Tabanus thoracinus, Pal. de Beauv., a species which is common in Uganda, and may therefore be expected to occur in the Bahr-El-Ghazal, is closely allied to *T. par*, with which it agrees in the colouration of the body, and in the narrowness of the front. *T. thoracinus* may, however, be distinguished by its generally larger size (the average length of the female is 13 mm.) by its brownish wings, and especially by the front tarsi and tips of the front tibiæ being dark brown. *Tabanus par* and *T. thoracinus* belong to a group of species (two or three of which, found in the Congo Free State and Abyssinia, have yet to be described) characterised by the yellow or ochraceous colour of the body, and by the narrowness of the front in the female sex. No males of these species are at present available for comparison, but since the eyes in the females are sparsely covered with minute hairs (often difficult to see when the specimens are not in perfect condition), while there is no trace of an ocellar tubercle, it is clear that, if thought advisable, the species may be assigned to the sub-genus *Atylotus*, Osten Sacken.

Tabanus ditæniatus, Macq.

(Fig. 22)

Tabanus ditæniatus (sic), Macquart, Dipt. Exot., I., 1 (1838), p. 126; Bezzi, Ann. Mus. Civ. di Storia Naturale di Genova, Ser. 2a, XII. (XXXII.) (1892), p. 184. Tabanus ditæniatus

Atylotus nigromaculatus, Ricardo, Ann. Mag. Nat. Hist., Ser. 7, VI. (1900), p. 165.

(N.B.—This synonymy is new.)

The following is a description of the female of this species.—♀ (11 specimens), length 11 to 14 mm.

Greyish-yellow; a pair of conspicuous shining black dots on the front; abdomen with three longitudinal blackish or brownish stripes on the centre one of which is a yellowish pollinose stripe.

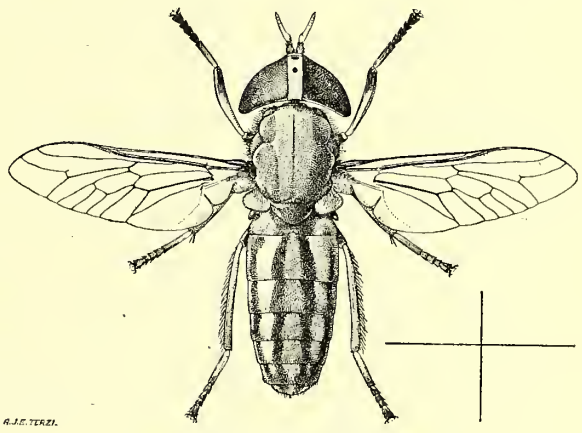


FIG. 22.—TABANUS DITÆNIATUS, Macq. ♀ Natal to the Bahr-El-Ghazal.

Head and thorax yellowish; abdomen ochraceous-buff with dark brown, somewhat serrate longitudinal stripes; antennæ yellow; legs yellow; front tarsi entirely, middle and hind tarsi, except at base, brown.

Head whitish (vertex buff); the shining black dots on the front one above the other, the lower just above the angles of the eyes, the upper about the width of the front higher than the former; antennæ ochraceous-buff, first joint paler; under side of head clothed with whitish hair; palpi white or yellowish white, clothed on outside with yellowish interspersed with minute black hairs; eyes in dried specimens usually with a narrow dark transverse band on a level with lower dot on front.

Thorax: dorsum blackish, yellowish or greyish pollinose and clothed with short golden yellow hair.

Abdomen ochraceous-buff, with a broad blackish or brownish median stripe (sometimes with slightly serrate edges), and a similar narrow stripe on each side; the lateral stripes are not in contact with the actual lateral margins of the abdomen, and all three stripes meet together at the tip; in the middle line, superimposed on the median stripe, is a yellowish pollinose stripe clothed with short golden yellow hair; this lighter stripe is really composed of a series of triangles with their apices truncated and directed forwards; the dark stripes are

clothed with black and the admedian ochraceous-buff stripes with yellowish hair. Ventral side of abdomen pinkish buff, clothed with pale yellowish hair.

Legs buff or ochraceous-buff; front tarsi and tips of front tibiæ dark brown; tips of middle and hind tarsi brownish; distal half of front tibiæ somewhat swollen; femora occasionally with a blackish patch on outside near base (in a ♀ from Mashonaland in the Museum collection the basal two-thirds of the front femora, and the basal half of the middle and hind femora are black).

Wings hyaline; veins pale yellow; upper branch of fork of third vein usually with a small appendix, which, however, is sometimes absent.

Halteres yellowish.

According to Macquart (*loc. cit.*) the ♂ of *T. ditæniatus* resembles the ♀. A ♂ from Estcourt, Natal, January 1897 (*G. A. K. Marshall*) in the Museum collection, which possibly belongs to this species, has the upper two-thirds of each eye (except the hind margin) composed of large facets, and the eyes show no trace of a transverse band. There are no dark lateral stripes on the abdomen, but on the dorsal side the tip of the abdomen from the fourth segment onwards (except the lateral margins), and a broad median stripe on the first three segments are entirely black; on the ventral side the extreme base, a median blotch which extends from the base to the middle of the third segment, a small median blotch on the hind margin of the third segment, and the last three segments are black; the fourth segment is also more or less blackish towards the hind margin and at the sides. The femora are black with the exception of the tips, otherwise the legs are as in the ♀, but the front tibiæ are not thickened.

Originally described from a specimen from Mauritius, *Tabanus ditæniatus* was subsequently recorded by Bezzi (*loc. cit.*) from Somaliland. The series of specimens of this species in the Museum collection shows that it is found from the Transvaal and Natal to Somaliland and the Bahr-El-Ghazal, where it was met with in February 1905 by Major R. H. Penton, D.S.O. The Museum collection also includes a ♀ from Angola (*J. J. Monteiro*).

Like the foregoing species, *T. ditæniatus* belongs to the subgenus *Atylotus*, though in the case of the female the hairs on the eyes are so minute and sparse as to be distinguishable only with difficulty. It is evident that *Tabanus agricola*, Wied., *T. fulvianus*, Lw., and *T. bipunctatus*, v. d. Wulp, are allied to *T. ditæniatus*, Macq., but without comparing the types it is impossible to say whether one or more of these names are actually synonyms.

Tabanus gratus, Lw.

(Fig. 23)

Tabanus gratus

Tabanus gratus, Loew, Öfv. af K. Vet. Akad. Förh., 1857, p. 340; Dipt.-Fauna Südafr. (1860), p. [114] 42.

A female specimen of this pretty little species, unaccompanied by details as to locality or date of capture, was forwarded by Dr. Balfour for identification during 1905. *Tabanus gratus* ♀ may be characterised briefly as follows:—

♀ (3 specimens), length 10½ to 11¼ mm.

Head greyish-buff above, with two conspicuous callosities on front; third joint of antennæ rufous; dorsum of thorax cinereous, with pearl grey longitudinal stripes; scutellum greyish chestnut; abdomen dark brown above, with three whitish or yellowish grey longitudinal stripes, converging towards the tip; legs ochraceous-buff; wings hyaline.

Head: face and jowls whitish pollinose and clothed with white hair; lower callosity on front pale ochraceous, squarish, and occupying whole width of front immediately above angles of eyes; upper callosity situated in middle of front, reddish brown and ovate; first joint of antennæ cream buff, with upper angle strongly produced, and capped with a tuft of minute black hairs, forming a black tip; second joint very small; third joint rather broad at base, with conspicuous basal angle; extreme tip of third joint dark brown; palpi somewhat swollen towards base, cream-buff, clothed with whitish hair interspersed with a few black hairs on outside.

Thorax: dorsum with a grey stripe on each side, and a narrow median and a pair of broader admedian stripes; the three latter are rather brighter in tint.

Abdomen: median stripe starting from a somewhat semicircular spot on hind margin of first and increasing in width from base of second to fourth segment, where it is broadest, then narrowing rapidly and terminating on hind margin of sixth segment; lateral stripes with a somewhat zigzag outline on outer side; lateral margin and under side of abdomen pearl grey.

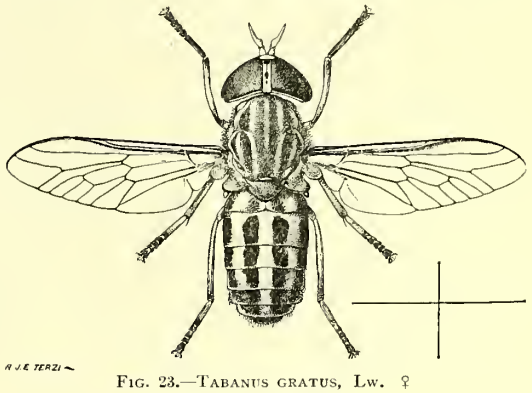


FIG. 23.—TABANUS GRATUS, Lw. ♀
South Africa to Nigeria
Head and legs yellowish, front tarsi entirely, middle and hind tarsi, except base, brown; thorax grey, abdomen brown, the former with light grey, the latter with whitish stripes.

Legs: front tarsi and tips of front tibiæ dark brown; last four joints of middle and hind tarsi, tips of middle and hind tibiæ and of first joints of middle and hind tarsi brown.

Halteres: knob pale yellow, stalk buff.

Tabanus gratus is evidently a widely distributed species, for, while the typical specimen is stated by Loew to have been collected in "Caffraria," the Museum series includes examples from Fajao, Victoria Nile, Uganda, November 1904. (*Captain E. D. W. Greig, I. M. S.*), and also from the vicinity of Yola, Northern Nigeria, April 14, 1905 (*W. F. Gowers*).

Tabanus socius, Walk.

(Fig. 24)

Tabanus socius, Walker, List Dipt. Ins. in coll. Brit. Mus., I. (1848), p. 160.

Tabanus socius

This species can be distinguished from *Tabanus virgatus*, Austen (*dorsivitta*, Walk.) (Fig. 26), which it closely resembles in general appearance, by the edges of the median grey longitudinal stripe on the abdomen being notched or serrate instead of smooth. To judge from the relative numbers of specimens in the British Museum collection, *Tabanus socius* would appear to be the commonest Seroot-fly on the White Nile. In addition to a very long series of examples taken at Kodok on December 6th, 1900, by the late Captain H. E. Haymes, the Museum possesses others collected and presented by Major H. N. Dunn, Captain S. S. Flower ("about ten miles south of Jebel Ain, White Nile, March 17, 1900"), and Major R. H. Penton, D.S.O. (Bahr-El-Ghazal, February, 1905). The species was found by Colonel G. D. Hunter, D.S.O. in May, 1905, on a boat in the sudd south of Nal Nusr, between Gondokoro and Taufikia, and Major Penton also met with it in Senaar, in 1899.

The type of *T. socius* is from "South Africa"; other specimens of the species in the Museum collection are from the Transvaal and the Congo Free State.

Tabanus virgatus, nom. nov.

(For *Tabanus dorsivitta*, Walk.,—nomen bis lectum.)

(Fig. 25)

Tabanus virgatus (Tabanus dorsivitta)

Tabanus dorsivitta, Walker, List Dipt. Ins. in coll. Brit. Mus., Part V., Supplement I. (1854), p. 231 (*nec T. dorsivitta*, Walk., Insecta Saundersiana. Diptera, part I. (1850) p. 39.)

Fig. 24.—Tabanus socius, Walk. ♀
S. Africa to the White Nile

Thorax greyish; abdomen rufous, with median greyish white longitudinal stripe bordered on each side with a dark brown zig-zag stripe; legs yellowish, front tarsi and tips of front tibiæ dark brown, middle and hind tarsi brownish.

Although the species is apparently less common in the Anglo-Egyptian Sudan than the foregoing, specimens of *T. virgatus* were taken on the White Nile in 1900, by Major H. N. Dunn, who also met with the species in Senaar, on the Blue Nile, in September, 1902.

The range of *Tabanus virgatus*, which is abundant in the Northern Nigeria and other parts of West Africa, includes the East Africa Protectorate and British Central Africa.

Tabanus biguttatus, Wied.

(Figs. 26, 27, ♂ ♀)

Tabanus biguttatus

Tabanus biguttatus, Wiedemann, Aussereuropäische zweiflügelige Insekten, II. (1830), p. 623.

Tabanus cerberus, Walker, List Dipt. Ins. in coll. Brit. Mus., I. (1848), p. 149.

Tabanus noctis, Walker, Insecta Saundersiana. Diptera, I. (1850), p. 42.

Tabanus tripunctifer, Walker, Appendix to the Zoologist for 1850, p. XCV.

(N.B.—This synonymy is new.)

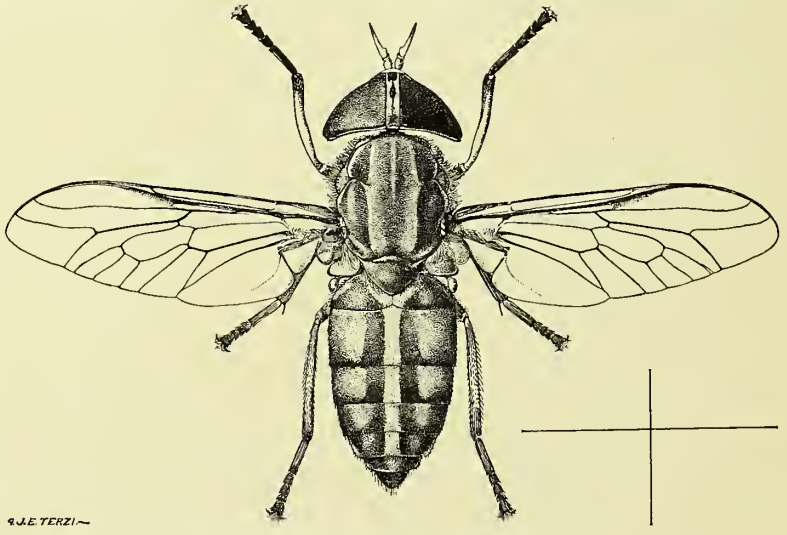


Fig. 25.—Tabanus virgatus, Austen. ♀
Gambia and Nigeria to Senaar and the E. Africa Protectorate

Thorax greyish with darker stripes; abdomen reddish, with light grey median longitudinal stripe; legs yellowish, with brown tarsi.

This is a common species of conspicuous appearance and large size, which it is hoped

will readily be recognised by aid of the figures on this page. It may be characterised briefly as follows:

♂, ♀.—♂. (11 specimens), length 16½ to 20 mm.

♀. (26 specimens), length 18 to 21½ mm.; wing expanse of largest ♀ 44 mm.

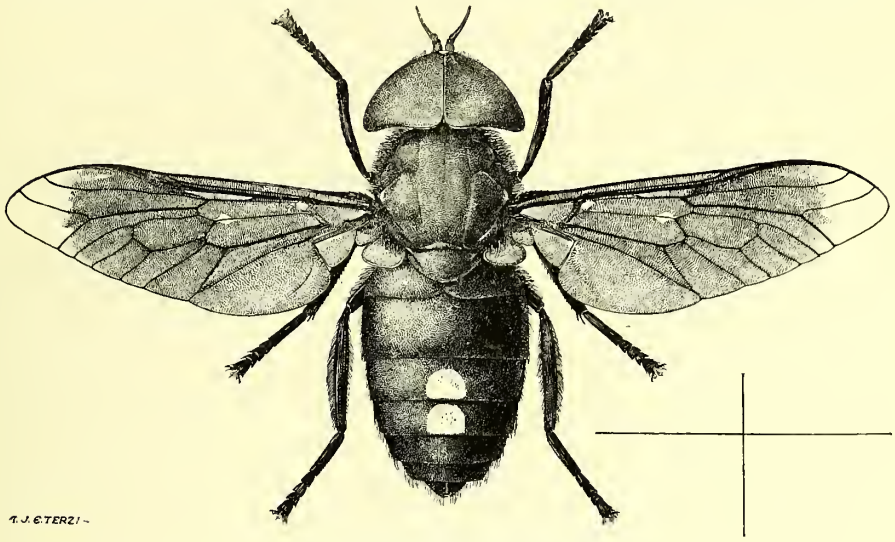


Fig. 26.—Tabanus biguttatus, Wied. ♂
Cape Colony to the Sudan, Abyssinia, and Aden
Deep black; abdomen with two cream-coloured spots; wings, except tips, dark brown.

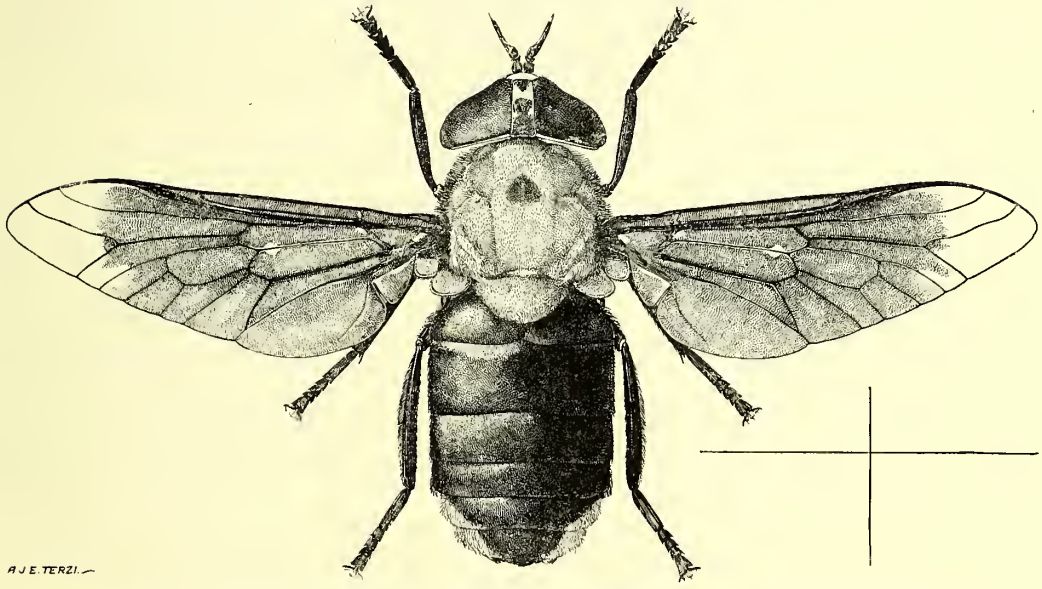


Fig. 27.—Tabanus biguttatus, Wied. ♀.
Deep black; front, face, jowls and dorsum of thorax clothed with golden-yellow or whitish-yellow hair; spot on thorax black; 5th and 6th segments of abdomen with yellowish hair at sides; wings as in ♂.

Deep black; ♂ with two cream-coloured spots, clothed with yellowish hair, one behind the other on dorsum of abdomen in median line; ♀ with front (space between eyes), face, jowls (part of head beneath eyes), and dorsum of thorax clothed with golden-yellow or whitish yellow hair, with an inverted cordate patch of black hair on dorsum of thorax in median line; in both sexes legs black, and wings except their apices (distal fourth or fifth) wholly dark brown.

This species thus shows a striking sexual dimorphism in the markings of the body. A curious aberration is, however, presented by two females in the Museum collection, from the Bahr-El-Ghazal, February, 1905 (*Major R. H. Penton, D.S.O.*), and the Hawash Valley, Abyssinia, 1901 (*A. E. Pease*), respectively, which actually have their abdomens spotted as in the male, though the spots in the case of the Abyssinian specimen are somewhat more triangular in shape; in addition, these two females also show traces of a patch or streak of yellowish hair in the median line on the second and fifth abdominal segments. Judging by the number of specimens of the two forms received up to the present time, in the Anglo-Egyptian Sudan females with pale hair on head and thorax would appear to be more common than those with golden-yellow hair on these parts. The same variation is seen in females from Uganda, and a female from Natal (Umfuli River) in the Museum collection also has the hair on head and thorax distinctly paler than in other females from the same colony.

As already mentioned, *Tabanus biguttatus* was met with in the Bahr-El-Ghazal in February of last year by Major R. H. Penton, who also found the species at Kodok in 1900; other specimens were taken by Major G. Dansey Browning, R.A.M.C., on November 6th and 7th, 1905, on a steamer on the White Nile near Kodok, and at Molub. Additional examples from the White Nile have been forwarded to the Museum by Major H. N. Dunn, R.A.M.C.; Captain S. S. Flower, Superintendent of the Zoological Gardens, Cairo (March 20th, 1900, "from about lat. 11.0° N."); and the late Captain H. E. Haymes, R.A.M.C. ("on boat on Nile, 30 miles south of the Sobat River)."

The range of *T. biguttatus* extends from Cape Colony to the Anglo-Egyptian Sudan and Abyssinia; the species also occurs further to the east in the Peninsula of Aden. In West Africa (Northern Territories of the Gold Coast and Northern Nigeria) there exists a form with pale palpi, which is possibly entitled to subspecific rank.

Tabanus fasciatus, Fabr., subsp. *niloticus*—subspecies nova

(Plate VI.)

Tabanus fasciatus niloticus

♀.—Length 15 to 17 mm.; wing-expanse $32\frac{1}{2}$ to $33\frac{1}{2}$ mm.

Head and thorax ochraceous-buff above, buff below, front sometimes ochraceous; abdomen (in dried specimens) pale maize yellow, somewhat tawny towards the tip, and on basal half usually with a suggestion of green; abdomen in life probably largely, if not entirely, apple green; wings with costal border as far as end of stigma, and a transverse band across middle, brown.

Head clothed beneath with golden-yellow hair; frontal callus of same colour as ground-colour, in width equal to about half the front; antennæ yellow mottled with green, tips tawny; palpi rather slender, pale yellow and clothed with pale golden-yellow hair, sometimes with a few minute black hairs towards the tips.

Thorax clothed above with short black hair, pleuræ with longer pale yellowish hair.

Abdomen clothed above with minute golden hairs, towards hind margin of third segment and on median area of following segments with minute black hairs.

Legs: femora and middle and hind tibiæ yellow or greenish-yellow; front tibiæ dark-brown, swollen, yellowish towards base above, and on lighter area clothed with short close-lying golden hair, elsewhere clothed with black hair; front tarsi black, middle and hind tarsi reddish-brown, lighter towards base; hind tibiæ fringed on outside with golden hair, inside clothed with shorter hair, yellowish on basal, black on distal half.

Wings: transverse band darker brown than costal margin, equal in width to length

PLATE VI

TABANUS FASCIATUS, FABR.—subsp. NILOTICUS, Austen (× 4)

of discal cell, and dying away on fore border of fifth posterior cell, before reaching hind margin; discal cell with a more or less conspicuous longitudinal pale streak; alula and squamæ dusky, margin of latter sometimes green.

Halteres: knob pale green, stalk yellow.

Described from a specimen from the Anglo-Egyptian Sudan, 1905 (received from Dr. Andrew Balfour). Type of subspecies in British Museum (Natural History).

Tabanus fasciatus niloticus seems to be common on parts of the White Nile and of the Bahr-El-Jebel. It was taken at Kodok in December 1900, by the late Captain H. E. Haymes, R.A.M.C., and, in the early part of the same year, also by Major R. H. Penton, D.S.O., R.A.M.C. Colonel G. D. Hunter, D.S.O., met with it on a boat at Abu Chok (between Gondokoro and Taufikia), on May 29, 1905, and Major Penton also took it in numbers in the Bahr-El-Ghazal in February of last year. Owing to its characteristic colouration and wing-marking it is easily recognised, and cannot be mistaken for any other species.

The new subspecies differs from the typical form of *Tabanus fasciatus*, Fabr., Systema Entomologiæ, p. 788 (1775), a common West African species found from Sierra Leone to the Congo Free State, in the colouration and hairy covering of the front tibiæ (which in the typical form are entirely black and clothed exclusively with black hair), in the colouration of the middle and hind tibiæ (yellow or greenish-yellow instead of black or dark brown), and in the hind tibiæ on the outside having a golden instead of a black fringe. The front tibiæ in *T. fasciatus niloticus* appear to be slightly more slender than in the typical form, the anterior curve being less abrupt. The wings in the typical form usually show no clear space in the discal cell.

The range of *T. fasciatus niloticus* extends at least as far south as Uganda, whence the Museum possesses a series of specimens from the Botanic Gardens, Entebbe, September 18, 1904 (*Captain E. D. W. Greig, I.M.S.*), Bugaya Island, Lake Victoria, and Ankole, August, 1903 (*Colonel D. Bruce, C.B., R.A.M.C.*). A specimen from Ankole, May 16, 1903, belongs to a form intermediate between the subspecies *niloticus* and the typical *T. fasciatus*, Fabr., since although the front tibiæ are pale at the base, the fringes on the hind tibiæ are on the distal half mainly composed of black hairs. A transitional form (as well as the typical one) is also found in the Congo Free State, where specimens are met with showing no golden hairs on the basal half of the front tibiæ, but with golden hairs, interspersed with the black or more or less predominant, in the fringe on the inner and outer side of the basal half of the hind tibiæ. A specimen of this form was also taken at Fajao, Uganda, in November, 1904, by Captain E. D. W. Greig.

Tabanus africanus, G. R. Gray

(Fig. 28)

Tabanus africanus, G. R. Gray, Griffith's "Animal Kingdom" (Cuvier), Vol. 15, p. 794, Plate 114, Fig. 5 (1832). Tabanus africanus

Tabanus latipes, Loew (*nec* Macq.), Die Dipteren-Fauna Südafrika's, p. [108] 36 (1860).

The identification of this species rests upon Gray's coloured figure, which is fortunately recognisable, for the original description consists of the single word "Fulvous." It therefore seems advisable to re-describe the species, more especially since the careful description of the ♀ by Loew (*loc. cit.*), besides being in German and published by its author under the name of the closely allied *Tabanus latipes*, Macq., can scarcely be accessible to the majority of those interested in the Blood-Sucking Flies of the Sudan.

♂, ♀.—♂ (2 specimens), length 17¼ to 18½ mm.

♀ (31 specimens), length 16¼ to 17 mm.; wing-expanse not exceeding 36 mm.

Tawny ochraceous; a patch of brilliantly white hair at base of wing on each side, and another and larger patch a little behind this, below posterior angle of thorax; legs black, front tibiæ swollen, especially in ♀; wings with base, two transverse bands, and costal border as far as upper branch of third vein, or almost to tip, brown.

Head orange-ochraceous, clothed with similarly coloured hair; antennæ and last joint of palpi (except base of latter) blackish; third joint of antennæ long and narrow, but little expanded at base.

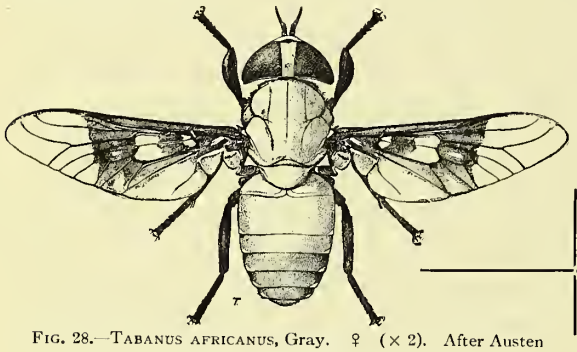


FIG. 28.—TABANUS AFRICANUS, Gray. ♀ (× 2). After Austen
Natal to the White Nile
Tawny ochraceous; legs black; wing markings brown.
By kind permission of Trustees of British Museum.

Thorax entirely without markings; in ♂ clothed with orange-ochraceous hair, in ♀ with short black hair above, and longer orange-ochraceous hair on sides and below.

Halteres: knob yellowish-white, stalk brownish.

Abdomen clothed above with short ochraceous-rufous hair, in the case of the ♀ interspersed with black hairs in median area towards tip; sides of fourth to seventh segments inclusive marked with a squarish black patch, clothed with black hair; posterior angles of these segments clothed with silvery-white hair; eighth segment entirely black: ventral surface—a black patch on sides of third to sixth segments inclusive in ♂ and third to fifth inclusive in ♀; last two segments in ♂ and last three in ♀ mainly black; hind margins of third to sixth segments in ♂ and third to seventh in ♀ whitish.

Legs: hind tibiæ fringed with black hair on inside and outside.

Wings: first transverse band terminates on fifth vein and runs across proximal half of both basal cells, *leaving a clear spot at their extreme bases;* second transverse band runs across middle of wing, is equal in width to length of discal cell, reaches hind margin at tip of fourth posterior cell, and dies away in fifth posterior cell; discal cell often entirely brown, but sometimes with a more or less conspicuous longitudinal clear streak; anal cell generally more or less tinged with brown, especially at tip; alula brownish; brown costal border dies away for some little distance beyond second transverse band, but broadens again above extreme tip of wing, the tips of second longitudinal and of upper branch of third vein being often conspicuously suffused with brown.

♂. *Head:* eyes with upper three-fourths, except hind margin, composed of much larger facets than those below; terminal joint of palpi cylindrical, pointed and clothed with black hair at tip, ochraceous at base; penultimate joint orange-ochraceous.

♀. *Head:* front broad, widening below and relatively short, its height equal to about two and a half times its width at the angles of the eyes; transverse callosity at angles of eyes brown, oblong, extending right across front and touching eye on each side; no trace of any other tubercle or line on front; terminal joint of palpi slender, under side of base orange-ochraceous and clothed with similarly coloured hair, elsewhere clothed with minute, black hairs.

Legs: front tibiæ much thicker than in ♂, anterior margin very convex.

Redescribed from a ♂ from Delagoa Bay, and a ♀ from Buvuma I., Lake Victoria, Uganda: types of redescription in British Museum (Natural History), and specially labelled.

This easily-recognised species, perhaps the handsomest of the African representatives of the genus *Tabanus*, was met with in the Bahr-El-Ghazal, in February, 1905, by Major R. H. Penton, D.S.O., R.A.M.C. A second specimen in the Museum collection, labelled "White Nile," was taken by Consul Petherick about 1862. As shown by the extensive series of specimens in the possession of the Museum, the range of *T. africanus* extends from Natal to the East Africa Protectorate and the Nile Provinces of the Egyptian Sudan, and westwards at least as far north as Angola. Although the possible distinctness of the two species was hinted at long ago by Loew (*op. cit.*, p. [109] 37), *T. africanus* has hitherto been confused with the closely similar *T. latipes*, Macq. (Diptères Exotiques, I. 1, p. 119 (1838)), which was originally described from Senegal. The latter species agrees with *T. africanus* in the coloration and markings of the body, as also in the general arrangement of the wing markings, but is distinguished by the brown on the costal border not being continued beyond the stigma (no infuscation at the tips of the second and of the upper branch of the third vein), and by the brown band across the middle of the wing not reaching the hind margin. *Tabanus latipes*, Macq., does not appear to reach South Africa, but apparently extends across the Continent from west to east, since the Museum possesses two females taken in Senaar, on the Blue Nile, in September, 1902, by Major H. N. Dunn; it is therefore possible that both *T. latipes* and *T. africanus* will be found existing together in Kordofan or the Bahr-El-Ghazal. It may be worthy of note that a female of *T. latipes* in the Museum collection, from the neighbourhood of Pawa, on the Katsina-Sokoto Boundary, Northern Nigeria, taken in August, 1904 (*the Acting Resident of Kano*, per Sir F. D. Lugard, K.C.M.G.), was received with four specimens of *Tabanus virgatus*, Aust., and a fifth *Tabanus* too much damaged to be determinable, with the following general label by the Acting Resident of Kano: "Wayam fly: kills horses."

Tabanus africanus and *T. latipes* are members of what may be termed the "Tabanus fasciatus *group*," the species belonging to which, in addition to the general yellowish, ochraceous or ferruginous colour of the body, are characterised by the possession of swollen front tibiæ and banded wings. Besides the species mentioned, the Museum collection includes representatives of three others which have yet to be described. *Tabanus maculatissimus*, Macq., which is found from Natal to British Central Africa, may be regarded as an offshoot of the group in question, since, although the front tibiæ are distinctly swollen, the ground-colour of the body is dark brown, the legs are pale instead of black as is usually the case in the *T. fasciatus* group, and the wings instead of being banded are blotched or speckled with brown.

NON-BLOOD-SUCKING SPECIES

Family MUSCIDÆ

Genus Pycnosoma, Br. and von Berg

Although the species of the genus *Pycnosoma* are incapable of sucking blood, they may very possibly play a part in the dissemination of such diseases as cholera and enteric fever, since their habits are similar to those of the House-Fly*. They swarm about filth trenches, and breed in fæcal matter and offal of all kinds.

Cf. E. E. Austen, "The House-Fly and Certain Allied Species as Disseminators of Enteric Fever among Troops in the Field": Journal of the Royal Army Medical Corps, June, 1904, pp. 1-16, Plates I. and II.

Pycnosoma marginale

Pycnosoma marginale, Wied.

(Fig. 29)

Musca marginalis, Wiedemann, Aussereuropäische zweiflügelige Insekten, II. (1830), p. 395.

Pycnosoma marginale, Austen, Annals and Magazine of Natural History, Ser. 7, Vol. XVII. (March 1906), p. 302 : *q.v.* for full synonymy.

In November 1905, this species was found by Major G. Dansey Browning, R.A.M.C., to be common on the Jur River, Bahr-El-Ghazal (Long. 8° 2′ N.), at ordure. *Pycnosoma marginale* is "a thick-set, stoutly built fly, with orange-buff-coloured face, and shining, metallic plum-purple or metallic green body, recognisable at once by the dark brown front border to the wings." * The species is distributed throughout Tropical and Sub-Tropical Africa, and is also abundant in the Transvaal and Natal; eastwards its range includes Arabia, and even extends as far as Quetta.

Fig. 29—Pycnosoma marginale, Wied. ♀
Tropical, Sub-Tropical, and S. Africa, and eastwards to Quetta.
Face, orange-buff; front, ochraceous-rufous; body, metallic plum-purple or metallic green, with dark bands on abdomen; legs, black; wings with a dark brown basal patch and stripe along fore border.

Pycnosoma putorium

Pycnosoma putorium, Wied.

(Fig. 30)

Musca putoria, Wiedemann, Aussereuropäische zweiflügelige Insekten, II. (1830), p. 403.

Pycnosoma putorium, Austen, Annals and Magazine of Natural History, Ser. 7, Vol. XVII. (March 1906), p. 303.

This common West African species, which is found from Sierra Leone to the Congo Free State, was met with by Col. G. D. Hunter, D.S.O., in May, 1905, on a boat on the White Nile, a few miles north of Melut, and also to the south of Lake No.

Fig. 30.—Pycnosoma putorium, Wied. ♀
Sierra Leone to the Congo Free State and the Egyptian Sudan.
Body metallic bluish-green, last two segments of abdomen brassy; transverse bands dull blue-black.

* Austen, Journal of the Royal Army Medical Corps, *loc. cit.*, p. 13.

Report on Economic Entomology

BY

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PART I

Second Report on the Mosquitoes or Culicidæ of the Sudan

Several mosquitoes new to the Sudan have been collected during the past year, including a representative of a new genus and three new species. The males of three species described in the last report have also been found.

A slide has also been sent of some aquatic larvæ which were said to be preying on the mosquito larvæ in pools. This cannot be reproduced, nor can the larvæ be identified. Some are young Dragon Flies (Odonata).

The new genus described here comes near Stegomyia and has been called *Quasistegomyia;* the species much resembling the East Indian *Stegomyia scutellaris* (Walker).

Another new species is placed in Mansonia, but I am not sure if there are not traces of flat scutellar scales, if so, it must be excluded from that genus and must constitute the type of a new one.

The species new to the Sudan but previously known in Africa are *Cellia squamosa*, Theobald; *Culex luteolateralis*, Theobald; *Culex hirsutipalpis*, Theobald; the males of *Myzomyia nili*, Theobald, and *Uranotænia balfouri*, Theobald, are described, and two other new Culex, named *Culex rubinotus* and *Culex neavei*.

Ædeomyia squammipenna (Arribalzaga) should have been included before as it was recorded in my Monograph in 1903, and now Colonel Penton, P.M.O., has found it again. Dr. Balfour has also bred *Culex tigripes* of Grandpre.

There are probably a great number of Sudanese Culicidæ, but they must be systematically collected and bred and their larvæ and pupæ kept, so that they can be properly described before we shall make much progress in the matter. Damaged material is useless, so are larvæ if we do not know the adults they give rise to.

Genus Anopheles, Meigen
Syst. Beschr. I., 10. (1818)
Mono. Culicid. I., p. 115 (1901) and III., p. 17 (1903)

Anopheles welleomei, Theobald. First Rept. Gord. Coll. Well. Labs., p. 64 (1904) Anopheles wellcomei

Fresh specimens of this species have been taken by Colonel Penton on the Jur and at Meshra.

It has also occurred in the Aden Hinterland, specimens having been sent me by Captain Patton, I.M.S., who, however, does not agree that they belong to any species. I can only say that they *are* the same as the specimens I described from the Sudan.

The male has not yet been found.

Genus Myzomyia, Blanchard. (Grassia, Theobald)

Myzomyia nili

Myzomyia nili, Theobald. First Rept. Gord. Coll. Well. Labs., p. 66 (1904)

The female of this species was described in the last report. No males had then been found. Three have since been sent me by Dr. Balfour, but no more females, there is no doubt, however, as to the species.

Male. Head brown with bright grey sheen, the median upright-forked scales creamy grey, the lateral dark brown, a median tuft of grey scales between the eyes; antennæ bright ochreous brown with deep brown verticillate hairs, the long apical segments brown, the large basal segment deep brown; proboscis long and thin, deep brown, the scales closely appressed; palpi (Fig. 31, A) with the last two segments swollen, the apical one ends bluntly acuminate and is about half the length of the penultimate; the palpi are brown except the apex on which there are grey scales, there are also golden brown hairs on the last two segments; clypeus brown; there are also two bright golden chætæ projecting between the eyes.

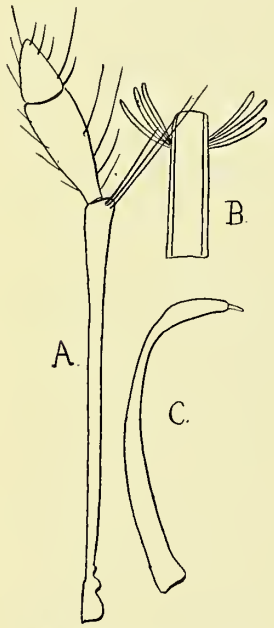


Fig. 31.—Myzomyia nili, Theob.
A Male palp;
B Process on male genitalia;
C Clasper.

Thorax deep brown with a greyish sheen, the deep brown also appearing as indistinct lines on the grey area; in front projecting over the head is a tuft of long, narrow-curved grey scales, the surface of the thorax ornamented with golden curved hair-like scales and scanty golden brown bristles; scutellum brown, paler at the edge with numerous pale golden brown border-bristles; metanotum brown; pleuræ ochreous brown.

Abdomen brown with a median darker line, shiny, with pale golden hairs.

Legs deep brown, thin and long, with traces of pale areas at the apices of the tibiæ; fore ungues unequal, the larger uniserrated, the smaller very minute, simple, looking like a second spine to the larger one; mid and hind equal and simple.

Wings mostly black scaled, with three creamy white costal spots spreading on to the first long vein across the subcostal; the scales are also pale on the base of the fork-cells and at the cross-veins, also on the lower branch of the fifth and on its stem and on the sixth; fringe dusky, traces of pale area at the lower branch of the fourth and upper branch of the fifth; first fork-cell considerably longer, very little narrower than the second posterior cell, its stem about two-thirds the length of the cell; stem of the second posterior longer than the cell by about half the cell's length; mid cross-vein a little nearer the apex than the supernumerary, the posterior not quite its own length nearer the base than the mid cross-vein.

Male genitalia (Fig. 31) with the claspers (C) curved apically where they are slightly swollen, a longish median process between the two basal lobes with three broad sword shaped chætæ on each side, near the apex (B).

Length. 3 to 3·5 mm.

Habitat. Lado. (Sheffield Neave, Esq.)

Time of capture. February.

Observations. Described from three perfect males.

The females were taken at Jebel Akmet-Aga on the White Nile, also on the Middle Sobat.

Myzomyia funesta, Giles. Hand Bk. Mosq., p. 162 (1902), Giles; Mono. Culicid. I., p. 178 (1901), and III. p. 34 (1903); First Rept. Gord. Coll. Well. Labs., p. 68 (1904). Myzomyia funesta

Dr. Balfour writes that this common African species has been taken in numbers on the Blue Nile. Colonel Penton also took it on the Jur and at Meshra.

Genus Cellia, Theobald

Mono. Culicid. III., p. 107 (1903)

Cellia squamosa, Theobald. *Anopheles squamosa*, Theobald Cellia squamosa

Mono. Culicid. I., p. 167 (1901) and III., p. 109 (1903)

This Anopheline has been taken by Colonel Penton, P.M.O., at Meshra, in the Bahr-El-Ghazal.

It has been recently sent me from Godokoro as well, by Dr. Aubrey Hodges. It also occurs over Uganda, Mashonaland, and the Transvaal. It was originally described from specimens taken in Mashonaland by Mr. Marshall and in British Central Africa by Dr. Daniels.

This Cellia is very marked and can at once be told from the other member of the genus found in Egypt and the Sudan, viz. *C. pharœnsis* (Theob.), by its black colour and white markings. There are white scales on the thorax, three white lines on the pleuræ, and black, bronzy and ochreous scales on the black abdomen, which has also black lateral tufts of scales. The dark scaled wings have three prominent, and two small basal white costal spots, and the legs are mottled and banded with white. I have not yet seen a male of this Cellia. It will probably be found all along the Nile.

Genus Myzorhynchus, Blanchard

Comp. Rend. Hebd. Soc. d. Biol. No. 23, p. 795 (1902)

Mono. Culicid. III., p. 84 (Theobald)

Myzorhynchus paludis, Theobald. Repts. Malarial Comm. Roy. Soc. Eng., p. 75 (1900); Mono. Culicid. I., p. 128 (1901) and III., p. 86 (1903); First Rept. Gord. Coll. Well. Labs., p. 70 (1904). Myzorhynchus paludis

This species has been taken in abundance by Colonel Penton on the Jur and at Meshra during the past year.

It is evidently common in the Bahr-El-Ghazal.

Genus Quasistegomyia, nov. gen.

Head (Fig. 32, A) clothed with flat scales; palpi short and spatulate in the ♀; clypeus with a distinct carina and lateral prominences. Second segment of the antennæ much larger than the following ones. Mesothorax (B), with narrow-curved scales of two sizes and with two pronounced areas of *flat scales before the scutellum* (*a*), one on each side of the bare area in front of it; scutellum (C) with flat scales.

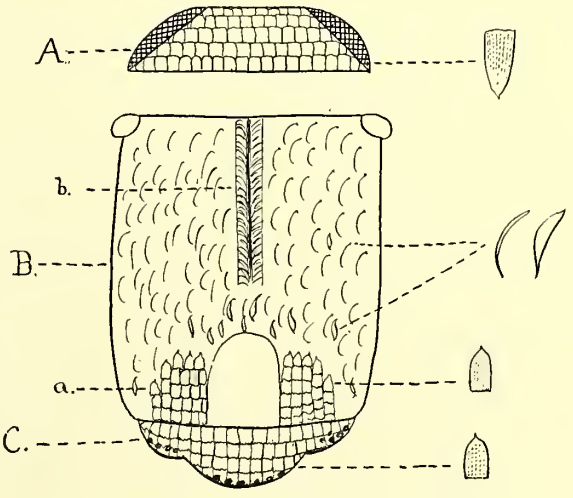


Fig. 32.—Quasistegomyia unilineata, n. sp.

A Head; B Mesothorax; *b* median silvery line; *a* Flat scaled area of the mesonotum; C Scutellum

Abdomen and legs normal. Wings densely scaled, with long, straight, rather broad, linear scales, and short, broad, flat, median ones; the branches of the fifth long vein nearly as long as the stem; the fringe long, the median sized scales apparently all crossing the large ones; costal border spiny.

The ♀ palpi are apparently composed of three segments, the basal one very small; the second smaller than the third, which is as long as the rest of the palp, swelling apically, the apex truncated, and on the inner side are two slight notches (Fig. 33, B). In Stegomyia they are the same size apically, tapering to an abrupt acute end (A). This genus comes close to Stegomyia, but differs in (1) the marked flat scales on the mesonotum, (2) the wing scales, and (3) in the peculiar ♀ palpi and also in (4) the swollen second antennal segment. The only species yet found occurs in the Sudan.

Quasistegomyia unilineata, n. sp.

Quasistegomyia unilineata

Head black with a median white line; palpi black with white apex; proboscis, black. Thorax deep brownish black with a median white line, divided by a very narrow dark line. which extends about half the length of the mesothorax, there are two small white spots where it ends and a white patch in front of the roots of the wings, also a few white scales before the white scaled scutellum. Abdomen black with traces of narrow white basal bands and large white basal lateral spots. Legs black, base of femora white and with some of the segments with basal white bands. Wings brown scaled.

♀ Head black, clothed with flat black scales with a broad median area of flat white ones about three and four scales wide, and a few snow-white small flat scales projecting between the eyes, bristles black.

Clypeus black with a distinct ridge which ends in a lateral prominence on each side; proboscis wide, deep black; palpi black scaled with snow-white apical scales, swollen apically; antennæ black, basal segment black with a patch of snow-white scales on the inside.

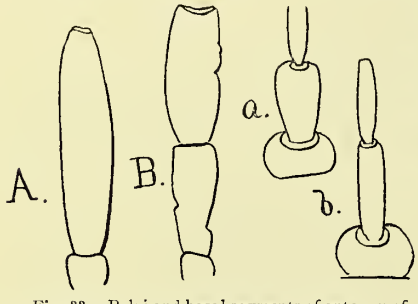


Fig. 33.—Palpi and basal segments of antennæ of *Stegomyia scutellaris*, Walker (A and *a*), and of *Quasistegomyia unilineata*, n. sp., B and *b*

Thorax black, clothed with deep bronzy-brown narrow-curved scales, ornamented with a median line of narrow-curved almost hair-like white scales, with a very narrow bare line in the middle showing as a narrow dark line. This extends about half across the mesonotum. Just behind where it ends are two small white-scaled spots, one on each side; over and in front of the roots of the wings is a patch of broader snowy-white scales; behind, bordering the sides and overlapping the bare space in front of the scutellum, numerous, irregularly placed, broadish narrow-curved scales, and on each side of them near the scutellum a large patch of flat black scales; the whole mesonotum is very bristly, the chætæ large and black; scutellum ochreous with flat white scales and with a few (3 ?) black border-bristles to the mid lobe; metanotum dusky black; pleuræ dark brown with flat white scales. Abdomen black with dusky black scales, each segment with a more or less narrow band of white scales which are most pronounced laterally. There are also very prominent large white basal lateral patches, separated from the abdominal bands; posterior border-bristles small, very pale golden.

Legs black, bases and venter of femora pale grey to white; metatarsi and first two tarsi of all the legs basally banded with white; in the fore legs the banding of the second tarsal,

almost imperceptible (last tarsi of hind legs absent). Ungues equal (simple ?). Wings rather densely scaled with long lateral, rather broad, scales, and with short broad median ones, first sub-marginal cell longer but scarcely any narrower than the second posterior cell, its base about level with that of the second posterior cell, its stem about two-thirds the length of the cell; stem of the second posterior cell nearly as long as the cell; posterior cross-vein sloping towards the base of the wing, about three times its own length distant from the mid cross-vein; the branches of the fifth long vein very long, the cell being nearly as long as the stem; fringe long and dense, especially at the apex where the scales are broad and sword-shaped; the median sized fringe scales slope across the long ones.

Length. 3·5 mm.

Habitat. Bahr-El-Ghazal (Major Bray).

Time of appearance. September (1905).

Observations. In general appearance this species is just like the *Stegomyia scutellaris* of Walker. It was nearly placed on one side as such, but luckily the flat scales on the mesonotum at the sides of the bare space in front of the scutellum were noticed. The median silvery line also shows a central, dark, thin line, not seen in the Eastern species, nor are the two small thoracic spots. There are also marked peculiarities in the wings, palpi and antennæ, so that it must clearly be placed in a new genus. The specimen bears a note, " bred from a tree," presumably from a larva taken in a hollow tree. It is said to be a very irritating species.

The hind legs were too damaged to describe. The specimen was collected by Major Bray. *Stegomyia scutellaris* (Walker) is also a tree and bamboo breeder.

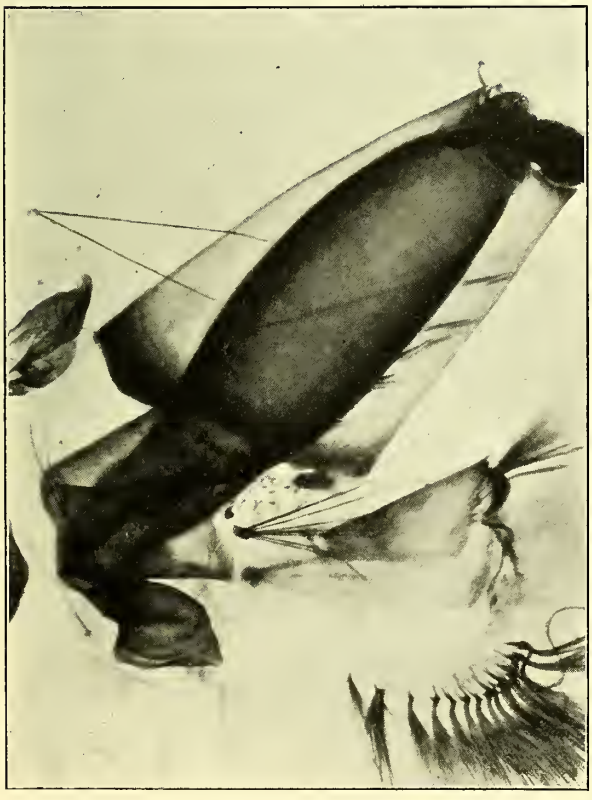


Fig. 34.—Larval siphon of Theobaldinella spathipalpis, Rondani.

Genus Theobaldinella, Blanchard.
Theobaldia, Neveu-Lemaire

Comp. Rend., d. Ss. d. l. Soc. Biol., 29 Nov. (1902)

Mono. Culicid. III., p. 148 (1903)

Theobaldinella spathipalpis, Rondani

Theobaldinella spathipalpis

Dipt. Ital., Prodro., I. (1886); Mono Culicid. I., p. 339 (1901), and III., p. 154 (1903)

First Rept. Gord. Coll. Well. Labs., p. 73 (1904)

This species has been found again in the Sudan, and Mr. Willcocks sends me many from Egypt.

Larvæ and pupæ have been found in Khartoum, and are described here as they have not previously been examined and figured.

The specimens are badly mounted so that only a few characters can be given.

The larva when mature is 8 mm. long. The head is bright chestnut brown, with black eyes and band across the nape, not so wide as the thorax. Thorax and abdomen greenish-brown ; siphon brown. The antennæ (Fig. 35, D) are simple and tubular, and end in a short spine or two ; on the side towards the apical half is a three-rayed bristle, in a line between the antennæ are two-median single bristles, and one on each side composed of three rays ; projecting from the front of the head are two flat curved spines ending in three digit-like processers (B) ; the clypeus (C) is acutely triangular, the bases are drawn down on each side, the lateral serrations numerous and small ; just in front of the eyes is a four-rayed bristle.

The thorax bears long dense lateral plumose tufts, with smaller short simple tufts in four rows dorsally.

The first three abdominal segments bear a tuft of several plumose chætæ on each side, the fourth three setæ, and the next three two setæ. The siphon (A) is short and thick, and bears two combs of seven long, thick, thorn-like spines; the axial papillæ are bluntly acuminate.

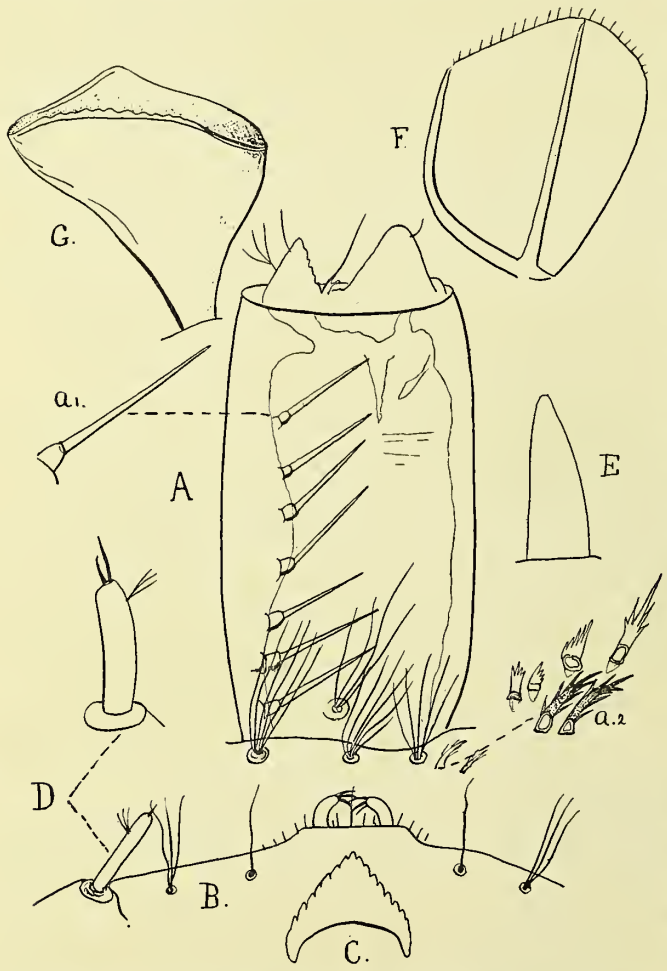


Fig. 35.—Larval and pupal characters of *Theobaldinella spathipalpis*, Rondani A Larval siphon; *a* 1 spine of siphon; *a* 2 of comb; B Anterior region of head; C Clypeus; D Antenna; E An anal plate of larva; F Anal plate of pupa; G Siphon of pupa.

The *pupa* is 5 mm. long, the two thoracic air siphons (G) are large and much expanded, one free border being raised into a prominence, the segments are deeply indented ventrally; the two anal plates are very broad (F), and the free end finely ciliated along the border, the axial rod is asymmetrical; there are simple bristles on the head, compound tufts on the thorax, that on the posterior dorsal surface of the last segment most prominent.

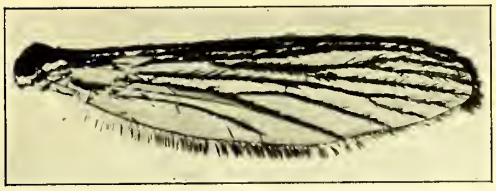
Genus CULEX, Linnaeus
Syst. Nat. Linn. (1735) ; Mono. Culicid. I., p. 326 (1901)

Culex hirsutipalpis

Culex hirsutipalpis, Theobald.
Mono. Culicid. I., p. 379 (1901)

A single female from El Obeid, in Kordofan, sent by Dr. Balfour, and collected by Captain Hughes. It is quite typical but does not show the two pale thoracic spots seen in most specimens.

This Culex was originally described from Mashonaland, it also occurs commonly in the Transvaal, Gambia, Gold Coast, and is probably existing all over Africa.



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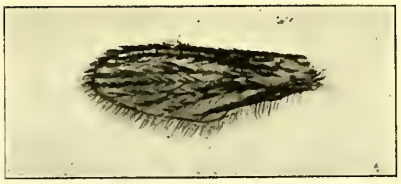

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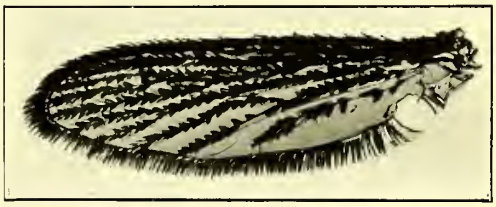

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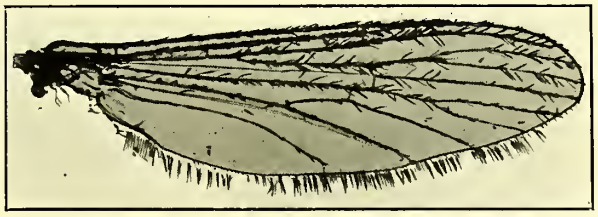

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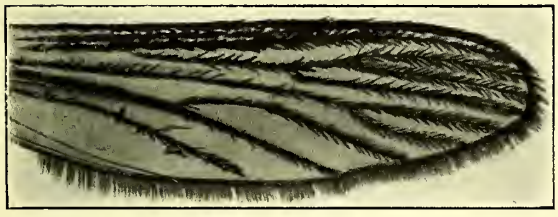

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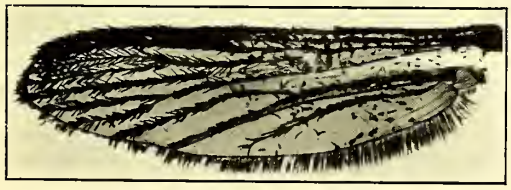

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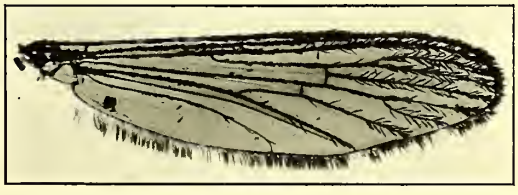


10

WINGS OF SUDANESE MOSQUITOES

1 Stegomyia scutellaris, Walker ♀
2 Quasistegomyia unilineata, n. sp. ♀
3 Myzomyia nili, Theobald ♂
4 Mansonia nigra, n. sp. ♀
5 Cellia squamosa, Theobald ♀
6 Culex luteolateralis, Theobald ♀
7 Culex hirsutipalpis, Theobald ♀
8 Culex pallidocephala, Theobald ♂
9 Culex neavei, n. sp. ♀
10 Culex rubinotus, n. sp. ♀

The thorax is brown, covered with deep golden brown scales, and some pale creamy ones, the latter usually form two more or less distinct spots on the mesonotum, there are also paler scales in front of the scutellum, over the roots of the wings, three rows of black bristles and many over the base of the wings. The proboscis is deep brown at the base and towards the end, the middle forming a broad pale band, the extreme apex is testaceous.

The abdomen is brown with basal semi-circular median yellow patches and basal lateral white spots.

The legs brown, the segments with apical and basal pale bands, except the last tarsal in the fore and mid legs, which are all dark brown. Ungues in female all equal and simple. In the male the proboscis has a narrow median pale band; the palpi are brown, longer than the proboscis by nearly the last two segments, apical segment acuminate with a narrow yellow apical band and a broad basal one, the penultimate segment also with a basal yellow band, the antepenultimate with a broad, pale band and a narrow one towards its base, hair tufts on the last two segments and the apex of the antepenultimate, long and black; fore and mid ungues unequal, both uniserrate, hind equal and simple.

The Sudan specimen measured 5·5 mm.

Culex luteolateralis, Theob. Mono. Culicid. II., p. 71 (1901)

Culex luteolateralis

A single ♀ of this very marked species, in bad condition, has been sent by Dr. Balfour. The only variation from the type is that the distribution of the yellow and black vein scales is slightly different.

Fig. 36.—Culex luteolateralis, Theob. ♀

The species can at once be told from any other known Sudanese mosquito.

The head has narrow-curved golden scales in the middle, flat ochreous and dusky ones at the sides; the proboscis is black and the palpi orange scaled at the base, black at the tip.

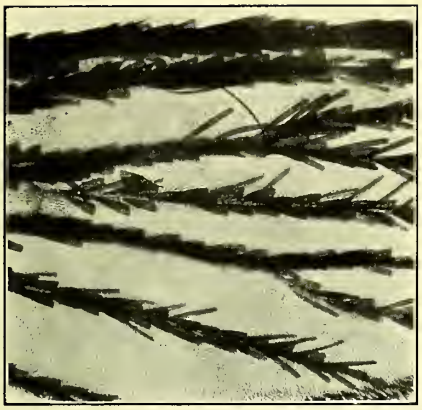
The thorax is deep black with a broad line of bright orange-yellow scales on each side of the mesonotum, there are also a few scattered gold scales amongst the narrow dull brown ones that adorn the middle of the mesonotum.

The abdomen is black with violet reflections and with basal creamy yellow bands to the segments, and also small lateral basal spots.

Legs dull ochreous with brown scales, unbanded, but the base and venter of the femora are ochreous; fore and mid ungues equal and uniserrated, hind equal and simple in the female. In the male the fore and mid ungues are unequal, both uniserrate, hind equal and simple.

The wings, in the type, are clothed with black and yellow scales, black on the costa and

PLATE VIII



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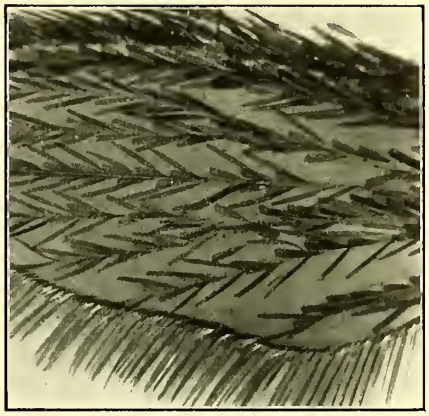

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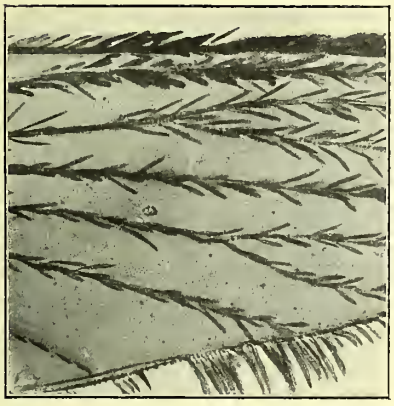

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6

ENLARGED WING SCALES

1 Stegomyia scutellaris, Walker ♀
2 Quasistegomyia lineata, n. sp. ♀
3 Myzomyia nili, Theobald ♂.
4 Cellia squamosa, Theobald ♀
5 Culex rubinotus, n. sp. ♀
6 Culex neavei, n. sp. ♀

on all the third long vein, on the branches of the fourth and some on the sixth, all the rest dull yellowish with a few dusky scales here and there. First submarginal cell longer and narrower than the second posterior cell, its base nearer the base of the wing than that of the second posterior cell, its stem less than one-half the length of the cell; posterior cross-vein more than its own length distant from the mid cross-vein.

In the Sudan specimen the yellow scales are confined to the base of the first longitudinal vein and along the stem of the fifth long vein, and a few may be detected here and there elsewhere.

Length of ♀ 3·5 to 4·5 mm.; ♂ 4·5 to 5 mm.

Habitat. Mashonaland, Natal, Transvaal, Gambia, Sierra Leone, Malay States.

The Sudan specimen came from the Blue Nile (Mr. Friedrichs). This insect has evidently a wide distribution for I can see no difference between those from Africa and those from the Malay States. Dr. Aubrey Hodges has recently written me that it is common around Gondokoro.

Culex neavei, n. sp.

Culex neavei

Head brown with a grey patch on each side; proboscis deep brown, unbanded. Thorax adorned with rich golden-brown scales. Abdomen brown, unbanded, but the segments with few scales at their base giving a quasi-banded appearance, all the segments with basal lateral white spots. Legs brown, unbanded, the femora pale grey ventrally and at the base; the hind metatarsi and tibiæ of equal length; wings of typical Culex form.

Female. Head brown, clothed with narrow-curved pale grey scales amongst which are numerous upright black forked scales (the general effect being brownish when seen with the hand lens only), on each side a patch of flat white scales; clypeus, palpi (Fig. 37, B 1) and proboscis deep brown; antennæ brownish black, the basal segment paler with a few pale scales. Thorax deep brown with narrow-curved golden-brown scales all sloping backwards with two more or less distinct parallel median bare lines, brown bristles which are numerous over the roots of the wings; prothoracic lobes with grey scales; scutellum pale brown with narrow-curved greyish scales and brown border-bristles; metanotum pale chestnut-brown; pleuræ pale grey with a few pale scales.

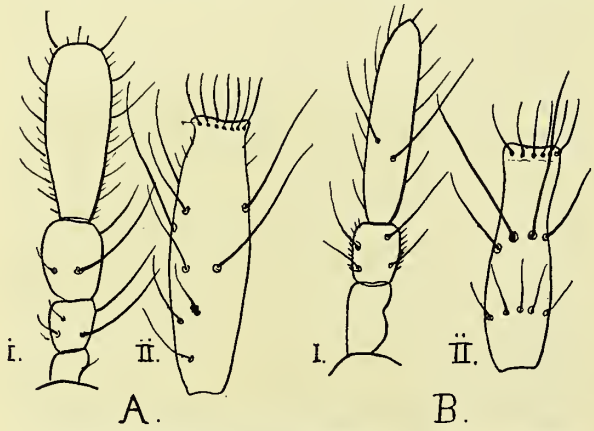


Fig. 37.– ♀ Palpi and Antennal Segment of (A) *Culex rubinotus*, n. sp., and (B) *Culex neavei*, n. sp.

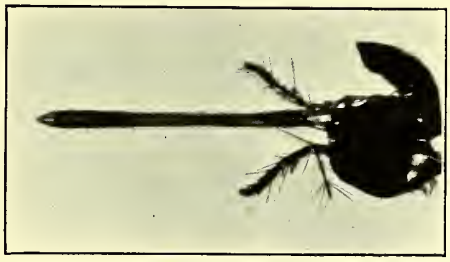
Abdomen pale greyish-brown covered with deep brown scales, which are thinly disposed at the base of the segments which thus present a faint false banding; basal segment pallid with two patches of dark brown scales from which arise two groups of short golden-brown hairs which curve outwards, and numerous longer pale-brown hairs from the body of the segment; posterior border-bristles of irregular sizes, indistinct, dull, pale and dusky-brown; each segment has prominent basal white lateral spots.

Legs deep brown, unbanded, femora all pale grey below, the hind ones grey above at the base as well, apex of the femora with a pale grey spot; hind metartarsi and tibiæ of equal length; ungues all equal and simple.

PLATE IX

1

2



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HEADS OF SUDANESE CULICIDÆ

1 Stegomyia scutellaris, Walker. ♀
2 Quasistegomyia unilineata, n. sp. ♀
3 Mansonia uniformis, Theobald. ♀
4 Culex neavei, n. sp. ♀
5 Culex rubinotus, n. sp. ♀

Wings with typical brown Culex scales; the first sub-marginal cell considerably longer but only slightly narrower than the second posterior cell, its base slightly nearer the base of the wing than that of the second posterior cell, its stem less than one-third the length of the cell, stem of the second posterior cell about two-thirds the length of the cell; posterior cross-vein nearly twice its own length distant from the mid. Halteres with grey stem and fuscous knob.

Length 4 mm.

Habitat. Luala's; Lado, Upper White Nile; (Sheffield Neave, Esq.).

Time of Capture. January (28/1/05), and February.

Observations. Described from three females, all in perfect condition, one gorged with blood and quite black.

The species comes near *Culex viridis* (Theob.), but can at once be told by the different wing venation, pale grey pleuræ, and from the next allied species by the hind metatarsi and tibiæ being the same length, and by the differences of the palpi and antennæ shown in Figure 37.

One specimen shows the stem of the first sub-marginal cell slightly longer than the rest.

The scales on the basal lobe of the antennæ I have not noticed before in any true Culex.

The species appears to be common, and may easily be confused with *C. viridis* and the other allied species described here.

Culex rubinotus, n. sp.

Culex rubinotus

Head brown with dull golden scales, creamy at the sides. Proboscis, palpi and antennæ, brown. Thorax, bright reddish-brown with scanty narrow-curved blackish scales. Abdomen clothed with deep blackish-brown scales and with traces of apical creamy-white lateral spots, no basal bands. Legs yellowish-brown clothed with dusky brown scales; hind metatarsi longer than the hind tibiæ.

♀ Head brown with small narrow-curved dull golden scales, some rather long; black upright forked scales and black bristles, pale creamy flat scales laterally; clypeus brown with an apparent median transverse sulcus indented in the middle; palpi (Fig. 37, A 1) densely scaled with deep brown scales and with numerous deep brown bristles, base testaceous, the scales being scanty; proboscis deep brown, swelling apically.

Thorax bright reddish-brown, with scanty, small, narrow-curved blackish scales (somewhat denuded) and with black bristles; scutellum the same colour with similar dark scales, posterior border-bristles of the mid lobe, six in number, three on each side with a wide median space; metanotum, pale ochreous brown; pleuræ, pale ochreous with a few flat dusky scales and small curved black chætæ.

Abdomen clothed with deep, dusky, blackish-brown scales, with traces of apical lateral creamy spots; basal segment testaceous with a median patch of black scales from which proceeds a line of a few dull brown chætæ, numerous other longer ones proceed from the nude part of the segment; posterior border-bristles dull golden-brown, long at the sides, shorter in the middle; venter with many pale creamy scales.

Legs unbanded, yellowish brown, covered with dusky brown scales, the ground colour showing through basally; ungues small, equal and simple; the hind metatarsi a little longer than the hind tibiæ.

Wings with the fork-cells rather short, the first sub-marginal cell much longer and narrower than the second posterior cell, its stem about one-third the length of the cell, its base nearer the base of the wing than that of the second posterior; second posterior cell

wide, the branches turning out at the apex, its stem about two-thirds the length of the cell; cross-veins large, the mid longer than the supernumerary, about the same length as the posterior one, which is distant from the mid nearly twice its own length; scales at the apices of the veins somewhat broader than is usual in Culex.

Halteres with pale stem and fuscous knob.

Length. 4 to 4·5 mm.

Habitat. Lualas, Upper White Nile (Sheffield Neave, Esq.).

Time of Capture. January.

Observations. Described from two females. The species is very marked, the bright reddish-brown thorax contrasting strongly with the dark unbanded abdomen. The thorax in both specimens is slightly denuded, but what scales remain are distinctly black and small. The structure of the second posterior cell is also characteristic. The abdomen shows (very indistinctly) apical lateral creamy spots. The female palpi are composed of four segments, the three basal ones are small, the apical one is as long as the basal three and ends bluntly; the apical segment is spinose, the penultimate has one long and several small chætæ, the antepenultimate has two long and some small ones.

Culex viridis, Theob.

Mono. Culicid. III., p. 212 (1903)

First Report Gord. Coll. Well. Labs., p. 73 (1904)

Culex viridis

A female and two males which resemble the type in all characters.

There are no structural differences from the type. They resemble specimens I have seen from Gambia and Uganda. The abdomen is unbanded, otherwise the species looks at first much like *Culex fatigans*, Wied., or *Culex pallidocephala*, Theob.

It has been recorded from Uganda, Gambia, Sierra Leone, and before from the Sudan (First Report, p. 73). The pleuræ are very green just as described in the type. The colour was not due to verdigris showing through the pale grey pleuræ as I at one time thought. The rich green pleuræ are very characteristic of the species. The female palp and second antennal segment show the difference between the two allied species and *viridis*, which I undoubtedly placed all as one in the previous report.

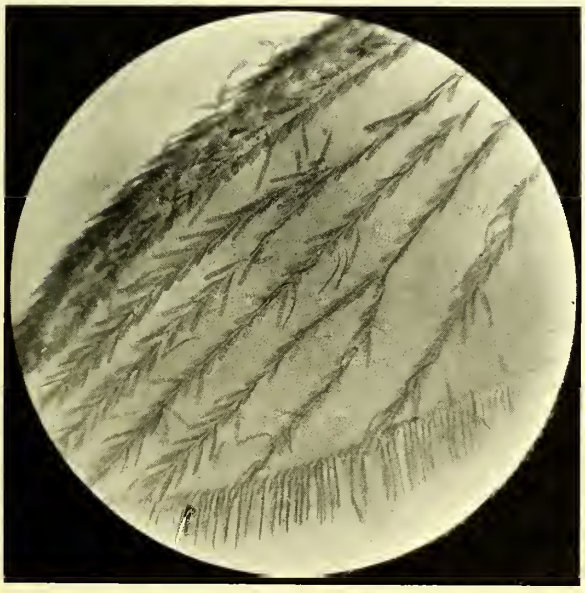

Fig. 38.—Culex pallidocephala, Theo. ♂

Culex pallidocephala, Theobald

First Report, Well. Labs., G. C., p. 73 (1904)

Culex pallidocephala

The female only of this species has been previously recorded.

Several males have recently been taken, from one of which the present description is drawn up.

♂ Head deep brown, with narrow-curved grey scales, with a median dividing line, numerous upright black and ochreous forked

scales and some black bristles; palpi dusky brown, almost black along the two apical segments and on the apex of the antepenultimate, traces of a pale band (very narrow) towards the base; hair-tufts deep brown; proboscis deep brown, thin.

Thorax much as in the female, but the scanty ornamentation not so distinct; pleuræ pale with indistinct patches of grey scales.

Abdomen deep brown, hairy, the segments with basal white lateral spots, the last segment with a basal white band, posterior border-bristles pale golden, short; lateral hairs very long, golden brown; basal segment testaceous, with two prominent tufts of black scales. Owing to scanty scaling the abdomen appears to be basally pale banded.

Legs deep blackish-brown, unbanded; the coxæ and base and venter of femora creamy white; a faint, pale, knee spot and a small spot at the apex of the tibiæ. Ungues of the fore legs and mid legs unequal, both uniserrated; the larger fore unguis more curved than the mid; hind ones equal and simple.

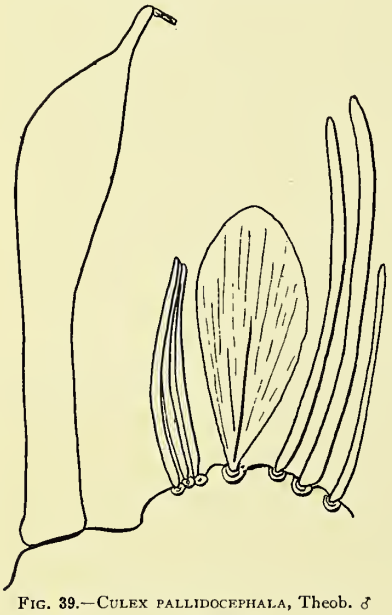

Fig. 39.—Culex pallidocephala, Theob. ♂
Left side of genitalia

Genitalia (Fig. 39), with broad flat claspers, ending abruptly in a narrow portion; the foliate plate very broad and with longitudinal striæ; three long flattened processes at the side, between the clasper and the foliate plate; the middle spines are the largest, the third of these are the shortest; there is also a single spine bent like a fish hook.

The two apical segments of the palpi of nearly equal length.

The vein scales on the apices of the veins rather broader than usual. First submarginal cell longer and narrower than the second posterior cell, their bases about level; stem of the first submarginal rather less than half the length of the cell; stem of the second posterior not quite as long as the cell; posterior cross-vein nearly twice its own length distant from the mid cross-vein.

Length. 4 mm.

Habitat. Upper White Nile.

Observation. Described from three males. Two have been dissected. The male genitalia are very marked, otherwise the male might be mistaken for *Culex viridis*, Theobald.

The pale pleuræ differs from the female type in which the pleuræ are dark, but the latter effect is undoubtedly due to the body being filled with blood.

The pale scaled head and scutellum should easily separate it without microscopic examination.

Genus Mansonia, Blanchard

Comp. Rend., Hebd. Soc. d. Biol., 37, T. liii., p. 1046 (1901)

Mono. Culicid. II., p. 173 (1901)

Mansonia (?) nigra, nov. sp.

Mansonia (?) nigra

Thorax very dark brown, with dark brown and golden scales forming an irregular ornamentation. Proboscis black, with a narrow white band towards its base. Abdomen black, with narrow, somewhat irregular, white bands and a few scattered white scales

and golden bristles. Legs deep blackish-brown, with some of the segments with narrow white basal bands, and a few scattered pale scales over the larger segments. Wings with very deep brown and white scales.

♀ Head deep blackish-brown, clothed with rather broad pale narrow-curved scales on the occiput, smaller narrow-curved golden ones around the eyes and pale upright forked scales, the sides with grey and black flat scales. Proboscis black scaled with a narrow white band towards its base, and a few white scales here and there on the apical part; palpi rather swollen apically, clothed with deep black scales, and with two irregular narrow bands of white scales on the basal half; clypeus black; antennæ very deep brown with brown verticillate hairs; basal segment deep black with grey sheen around the summit, and with some small flat creamy scales.

Thorax deep blackish-brown, clothed with narrow-curved, bronzy-brown scales and irregularly ornamented with broader narrow-curved golden scales, with broadish narrow-curved white and black scales at the sides, just before the roots of the wings; a marked pale area in front of the roots of the wings, and pale scales on each side of the bare space in front of the scutellum, much denuded, deep blackish-brown with curved pale golden scales on the mid-lobe, with, apparently, a few flat pale ones basally, side lobes with a few flat black scales; metanotum deep brownish-black; pleuræ deep brown, with small flat creamy scales.

Abdomen densely clothed with flat black scales, with irregular apical, very narrow bands of white scales, the last few segments with traces of median lateral creamy patches, and a few scattered pale scales over all the segments.

Legs black scaled, the metatarsi and first three tarsi of all the legs, with narrow white basal bands, and a few pale scattered scales on all the femora and tibiæ; ungues equal and simple.

Wings with large black and white Mansonia scales, those on the sixth vein large and irregularly heart-shaped; posterior border scales of the fringe large, with long apical serrations, continuations of the scale ribs; first sub-marginal cell longer and narrower than the second posterior cell, their bases nearly level, stem of the first sub-marginal rather more than one-third the length of the cell; stem of the second posterior rather more than two-thirds the length of the cell; posterior cross-vein about twice its own length distant from the mid.

Fig. 40.—Mansonia nigra, n. sp. ♀

Length. 4·3 mm.

Habitat. Sudan, Blue Nile (Mr. Friedrichs).

Observations. A very dark species, looking almost black, with paler markings. The wing scales present a slight modification in certain areas to the true Mansonia type, but most are normal. Those on the sixth vein are very large and irregularly heart-shaped.

Unfortunately the scutellum was partly denuded, but as far as I can detect there are

a few flat scales on the lateral lobes left and a few at the base of the mid lobe, if these are in their normal position the species must form the type of a new genus. As there were some other detached scales on the scutellum, clearly head scales, it may be that the flat ones are also stray ones from another part of the body.

The species is very marked, but the exact generic position must be left pro tem.

Dr. Balfour, who sent the specimen, pointed out that there were bluish-purple and green scales laterally on the abdomen. I could not detect these, probably owing to fading after death.

Genus ÆDEOMYIA, Theobald
Mono. Culicid. II., p. 218 (1901)
Ædeomyia squammipenna, Arribalzaga
Mono. Culicid. II., p. 219 (1901)

Ædeomyia squammipenna

This quaint Ædine was taken some years ago by Dr. Loat on a small lake eight miles from Gondokoro.

It has since been taken by Colonel Penton, P.M.O., on the Jur river, a tributary of the Bahr-El-Ghazal, in November.

This Ædine can be told at once by the Mansonia-like wing scales.

The thorax is brown, with scattered creamy scales, which become white at the sides and behind; the scutellum is ochreous with black scales on the side lobes, ochreous ones on the mid lobe.

The brownish abdomen has two patches of creamy scales on the apices and two patches of white scales on the base of the segments, the apical segments are often all yellow scaled. The legs are mottled and banded with creamy, purple and white scales, the apices of the mid femora having dense tufts of dark scales.

The wings have mottled yellow and deep purple-brown scales with normally three white costal patches, the two middle ones forming two bands going partly across the wings, the apical one also continues as a broken band around the end of the wing, and there is also a pale patch between each band in the middle of the wing field.

The length varies from 3·5 in the male to 4·5 in the female.

Dr. Balfour points out that the specimen taken by Colonel Penton has four silvery white wing spots, and the dense femoral tufts project forward anteriorly.

This insect occurs in South and Central America, West Indies, India, and Malay, and I expect Skuses' *Ædes venustipes* from near Sydney is the same insect.

It seems to inhabit houses and open country indiscriminately and bites, but not as a rule very severely.

Genus URANOTÆNIA, Arribalzaga
Dipt. Argentina, p. 63 (1899); Mono. Culicid. II., p. 241 (1903)
Uranotænia balfouri, Theobald
First Rept. Wellcome Res. Labs., p. 82 (1904)

Uranotænia balfouri

The female only has been described. In a recent small consignment sent me are two more much rubbed females and a nearly perfect male which is described here.

♂ Head deep brown, clothed in the middle with flat dusky scales, the sides with flat grey and blue scales, deep brown behind; there are also a few upright deep brown forked scales; cephalic chætæ black.

Antennæ plumose, the segments half brown, half grey; plume-hairs dark brown; basal

segment very large, deep brown; clypeus prominent, black; palpi very minute, deep black; proboscis black, swollen apically.

Mesothorax deep brown with narrow-curved brown scales, apparently a line of blue scales before the root of the wings as in the female; scutellum brown with deep-brown small flat scales and four bristles to the mid lobe; metanotum pale brown basally, dark brown apically; pleuræ brown with some pale and azure blue flat scales.

Abdomen as in the female. Legs deep brown with bronzy sheen (ungues absent). Wings with brown scales very similar to those of the female, and with a row of flat white scales at the base of the fifth long vein; the upper branch of the first fork-cell not as close to the first longitudinal vein as in the female; the stem of the second posterior about one and a half times the length of the second fork-cell, the mid cross-vein longer than the others.

Length. 2 mm.

Habitat. Goz-abu-Guma, White Nile. (Dr. Balfour).

Observations. Described from a nearly perfect male, but with somewhat rubbed body. The two females are just the same as in the type. The male wing venation cannot well be made out as only one wing was left on the specimen and that was crumpled, but the general appearance is that of the female.

PART II

Human and Animal Pests

The Maggot Fly

(*Bengalia depressa*, Walker)

Bengalia depressa

Dr. Balfour has had this insect sent him from the Bahr-El-Ghazal province, and has also given me a larva from the back of a native, which is undoubtedly the maggot of this fly. The Maggot Fly (*Bengalia depressa*, Walker), is a well-known human and animal pest in parts of Africa. It is also known under the generic name *Auchmeromyia*. The larva is, however, very different from that of *Auchmeromyia luteola* Fabricius, the Congo Floor Maggot.

The larva or maggot, which resembles a small "bot" or larval œstrid fly, lives under the skin, producing so-called cutaneous myiasis. There are other instances of cutaneous myiasis, notably in the Cayor Fly (*Ochromyia anthropophaga*, Blanchard) which attacks man in Senegal, especially in the south in Cayor. The larvæ called "ver du Cayor" develop in the skin of man, cats, dogs, jackals, etc.

A closely related species occurs in the South East of Africa. The larva of this fly is very similar to the one described here, which is evidently that of the Bengalia that occurs in the Sudan. The Bengalia occurs in numbers in Natal, but according to Fuller (1) the range of the fly seems limited to the coast and no further inland than the 1,000 foot elevation. It is common from the Tugela downwards, and is particularly abundant about Verulam and Durban, but not so much so to the south of the port. It is also recorded further up the coast from Delagoa Bay.

Mr. F. P. Mennell of the Rhodesian Museum, Buluwayo, informs (2) me "That like most undesirable insects, it seems to have its headquarters in Rhodesia." It also ranges into British Central Africa and Uganda.

The same correspondent says that around Buluwayo, 4,500 feet above sea level and 400 miles from the nearest point on the coast, it is common, while at Salisbury, 5,000 feet, it is an even more serious nuisance.

As it has now been found in the Sudan it is probable that it occurs all over Central Africa as well as on the East Coast.

The fly is half an inch long with wing expanse of about an inch. The head is large, with two prominent dark eyes, brown in color with yellowish brown between the eyes. The thorax is rusty- to yellowish-brown with dark lateral and dorsal chætæ. The abdomen is pale brown, darker at the apex with two dusky bands, pale below. The legs of a similar tint to the pale color of the thorax. The transparent wings are tinged, especially at their bases, with dusky brown. The fleshy mouth parts are not adapted to pierce the skin, on the other hand the female has a sharp needle-like ovipositor.

The *ova* according to Fuller, are elongated and white and about 3-50ths of an inch in length.

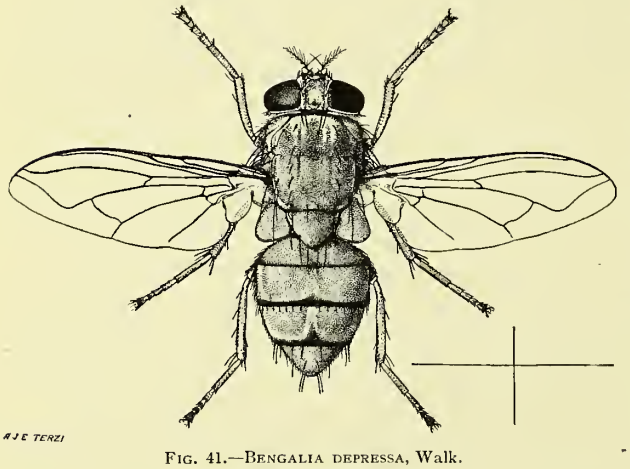

FIG. 41.—BENGALIA DEPRESSA, Walk.
Natal to the Bahr-El-Ghazal
Yellowish brown, margins of abdominal segments dark brown; legs same color as body; wings brownish.

The *larva*, which was obtained by Captain Lyle Cummins, is creamy white in color with deep brown spines. (Fuller describes the maggot as "of a white or dirty-whitish color and much besprinkled with minute black spots which, as a matter of fact, are really spines.)

When mature it reaches half-an-inch in length. The larva sent by Dr. Balfour, described here, is evidently immature being only 8 mm. long.

The cephalad area has two blunt processes, each of which bears a small blunt mammilliform process. The two mandibles which project ventrally, are very thick, curved and black, there being apparently a serrated basal plate to each one.

The first segment has on the dorsum short brown thorn-like spines on the anterior moiety, the posterior area being nude, and there are also two lateral pairs of short papillæ. At the base of this segment is noticed a small reddish-brown spot on each side; the second and third segments have short dark spines on their anterior moieties, especially pronounced on the second; the third, fourth, fifth and sixth segments have many similar spines all over them, the seventh has very much smaller, paler and scanty ones, the eighth and ninth have none. The anal segment bears two groups of spiracles, arranged three in each group; these are all curved, the two outer ones outwards, the middle curved towards the outer one; spiracular areas brown. The segments are deeply constricted and the spines are particularly prominent on the lateral borders.

Ventrally the larva is spiny just as it is dorsally.

The *puparium*, according to Fuller, is stout and oval, dark purple in color, and as a rule covered with a mealy down.

According to Mennell the fly deposits its eggs in the hair or clothing, the latter being

apparently often selected when hanging out to dry, so much so that in certain parts of Africa it is dangerous to wear woollen clothing next to the skin.

Fuller mentions that it is averred that the flies lay their eggs upon bedding. The sharp ovipositor seems to point to their being able to lay their eggs directly in the skin.

The eggs when laid in the former position hatch out rapidly, and the larvæ bury themselves under the skin. They at first produce a boil or swelling which leads to inflammation, which becomes most painful owing to the accumulation of excreta and the rasping movements of the spiny maggot. Occasionally this throws the patient into a violent fever.

In one case, recorded by Fuller, a child under six months had between twenty and thirty maggots taken from its scalp. In the majority of cases, Fuller states, the scalp seems the part most subject to invasion. They are, nevertheless, frequently found in the nose, back, chest, arms, buttocks and legs, and one case is recorded where the maggot occurred in the finger of a baby, and in two cases in the scrotum.

Mennell says that he believes that "if undisturbed, the larvæ emerge in the course of about a fortnight." Information on this point is given by Fuller, who was informed by a correspondent that he "noticed a maggot fly in his tent on the Tuesday of one week, and on the following Saturday suffered from an itching in the arm and chest. On Monday the spots had taken the form of blind boils, with a black speck in the centre of each. A week later maggots measuring one-third of an inch were expressed from the boils. The fly observed was caught and *living maggots* extruded from the abdomen when squeezed."

I have added the italics as this statement seems to point to the fact that the fly is at times viviparous.

Infection may take place either at night or during the daytime.

The adult is very sluggish in nature and does not move about on windy days.

Mennell has had the flies settle on him in the daytime and found them very difficult to drive away, but easily killed when they settle.

Pupation takes place on the ground just as in the *Œstridæ*.

After the maggot leaves the skin the wound heals rapidly if treated with antiseptics, but a very pronounced scar remains for a long time.

Besides man, *Bengalia depressa* attacks dogs, rabbits, and other animals.

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The Congo Floor Maggot

(*Auchmeromyia luteola*, Fabricius)

A specimen of this fly was taken by Dr. Sheffield Neave, in the Sudan. The fly is well known and is widely distributed in both tropical and subtropical Africa. Auchmeromyia luteola

Its interest lies in the strange habits and blood-loving propensities of the maggots of the fly which have been recently shown by Drs. Dutton, Todd and Christy (Reports of the

Trypanosomiasis Expedition to the Congo, 1903-1904. Memoir XIII., Liverpool School of Tropical Medicine, 1904).

The above-mentioned gentlemen showed that the maggots occur in numbers in the native huts in the Congo region. At night they crawl out of the crevices of the mud floors and from under the sleeping mats, and suck the blood of men, women and children, and then return to their shelters.

The maggots are normally dirty white, but after a meal of blood they become red in colour.

The following is the original description: "The larva is broadest at the ninth and tenth segments, is roughly ovoid in transverse section, and has, distinctly, dorsal and ventral surfaces. At the junction of the two surfaces is a row of irregular protuberances, two or more being placed on each segment. On each protuberance is a small posteriorly directed

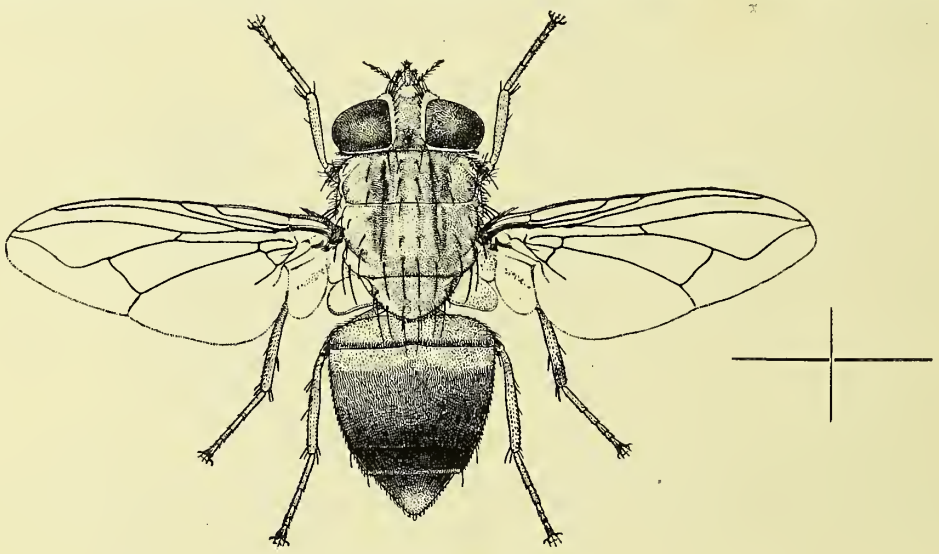


FIG. 42.—AUCHMEROMYIA LUTEOLA, Fabr. ♀
Nigeria to Natal.
Body and legs yellowish buff; broad dark band across abdomen bluish-black.
By kind permission of "Brit. Med. Journ."

spine and a small pit. The central part of the ventral point is flattened, and at the posterior margin of each segment is a set of three foot-pads transversely arranged, each covered with small spines directed backwards. These aid the larva in its movements, which are fairly rapid and peculiar in that the mouth parts are protruded to the utmost and the tentacula fixed, as a purchase, first on one side and then on the other, while a wave of contraction runs along the body as each segment is contracted and brought forward. The last segment is larger than the others. Its upper surface is flattened, and looks backwards and upwards at an angle of about 45 degrees with the longitudinal axis of the larva. This surface is roughly hexagonal and bears anteriorly, one on either side, the posterior spiracles, which are seen with a pocket magnifying glass as three transverse, parallel, brown lines.

"Around the flattened surface towards its border are placed groups of rather prominent spines. The ventral surface of this segment is also flattened, and is thrown into folds by muscular contractions. The anus is situated in the anterior portion of this segment in the middle line, and is seen as a longitudinal slit surrounded by a low ridge.

"Posterior to it, and on either side, is a large conspicuous spine. The anterior segment is roughly conical, and bears the mouth parts in front. Posteriorly, on the dorsal surface, are

two spiracles, seen with a low power as small brown spots. Two black hooks protrude from the apex of this segment. The apex of each hook is blunt, and its base surrounded by a fleshy ring. Between them is the oral orifice. Paired groups of minute spicular teeth are placed around the two tentacula so as to form a sort of cupping instrument.

"The arrangement of the teeth is as follows:—A rather large tubercle situated on either side of and above the tentacula; each is mounted by two or more groups of very small chitinous teeth. Just above each tentaculum is another small group of teeth. On either side of these black tentacula two irregular rows of small teeth are placed one above the other."

Their larvæ do not occur in the same way as those of the *Bengalia*, namely, under the skin causing true myiasis.

Annoyance caused by Stingless Bees

(*Melipona spp.*)

Mr. Harold Brown, of the Imperial Institute, sent me some bees from the Sudan which cause considerable annoyance. They prove to be *Melipona breccarii* Gribodo. Mr. Brown found them in numbers in the Bahr-El-Ghazal during a recent visit for the purpose of investigating the rubber vines of the country. They occur in enormous numbers in those parts of the forest where large trees occur. They do not sting but settle on one's face in considerable numbers, and unless constantly removed they persist in crawling into one's eyes, ears, and nose, and cause much irritation. When crushed they emit a very strong aromatic odour, something like very rank oil of rose geranium. Mr. Brown could not find any flower possessing a similar odour. Melipona spp.

The nest was observed by Mr. Brown who described it in his letter to me as follows:—"The nest is situated in the trunk of a large tree about seven feet from the ground; it had a short tubular opening apparently made of wax and about the thickness of a pencil which projected about three-fourths of an inch from the bark and was curved downwards. Through this passage there was a constant stream of insects going and coming."

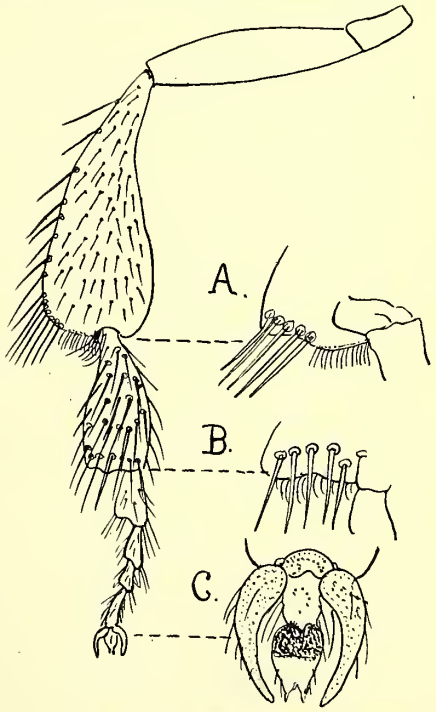


Fig. 43.—Hind leg of *Melipona breccarii* Gribodo (enlarged)

A Enlarged apex of tibia; B Wax cutting organ at apex of the first tarsal segment; C Ungues and pulvillus

The genus *Melipona* has a very wide distribution in America, Africa, Asia and Australia.

The members of the genus occurring in Burma also cause much annoyance to travellers by creeping into the mouth, eyes, and getting into the hair.

None of the genus possess stings. The annoyance is solely caused by the irritation produced by their movements and by their bites.

Bates, in his well-known work on the Amazon River, gives an account of one of this genus *Melipona fasciculata*, Smith, in America. He states that the workers may generally be seen collecting pollen, but many collect clay. They construct their combs in any suitable crevice in the trunks of trees or perpendicular banks, the clay is used to build up a wall to close the gap, a small entrance hole only being left. One species he mentions forms a trumpet-shaped entrance to the hive as Mr. Brown

observed. At this entrance several of these pigmy bees are stationed to act as sentinels. *Melipona fasciculata* produces a pleasant liquid honey, to the extent of about two quarts in each nest.

They bite furiously when disturbed. A large number of species occur in America—Bates found no less than forty-five—the largest being half an inch in size; the smallest one-twelfth of an inch, and he says "these tiny fellows are often very troublesome on account of their familiarity; they settle on one's face and hands, and in crawling about get into the eyes and mouth or up the nostrils."

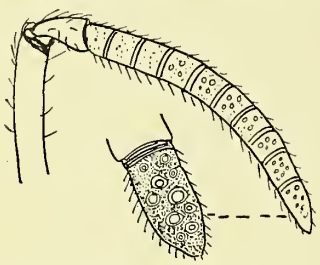


Fig. 44.—Apex of Antenna of *Melipona breccarii* Gribodo (enlarged)

The South American Spaniards call them "Angelitos" (little angels) because they do not sting.

These *Meliponæ*, nevertheless, cause great annoyance to man.

In a paper on Bees, by Riley (Insect Life, Vol. VI., p. 360) we learn that the *Meliponæ* construct cells of a dark unctuous wax in regular combs and are somewhat imperfectly hexagonal. They are, however, in single horizontal tiers, separated and supported by intervening pillars, more like the nests of the social wasps, and the cell is sealed after the egg is laid upon the stored food, just as in the case of solitary bees. The honey is stored in modified flask-shaped cells, and only one queen is allowed to produce eggs.

Sir Alfred Moloney, writing from British Honduras to Professor Riley in 1893, said, "a considerable industry might be locally developed in the wax." The species referred to was *Melipona fasciculata*, Smith.

The species from the Sudan have been named by Colonel Bingham, one of the chief authorities on Aculeate Hymenoptera, and he informs me they are *Melipona breccarii*, Gribodo (Ann. Mus. Civ. Grn., XIV., p. 340, 1879). This bee was originally described from Abyssinia.

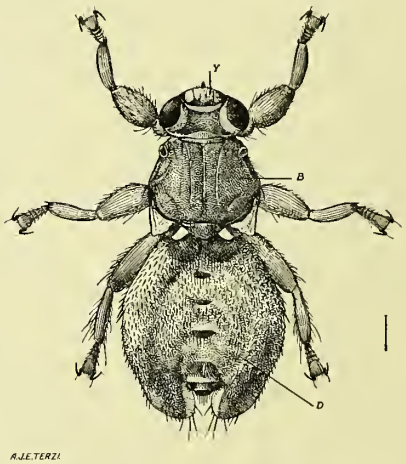


Fig. 45.—Lipoptera ibicis (n. sp.?)

Front of head yellowish brown; thorax, median area of head, and base of abdomen brown; remainder of abdomen dull yellowish or brownish, with median row of shining brown patches; legs yellowish brown.

Y yellowish brown; B brown; D dull yellowish or brownish

There was also a single specimen of *Melipona ruspolii*, Mayrette (Ann. Mus. Civ. Grn., XXXIX., p. 27, 1898).

The structure of the hind legs is very marked (Fig. 43).

A Pupiparous Dipteron

Lipoptera ibicis, nov. sp. (?)*

Female. Deep brown, with testaceous brown legs. Head wider than the anterior, narrower than the posterior part of the thorax, deeply sunk into the thorax. Antennæ completely imbedded in the sockets with three terminal bristles, the median slightly the longest. The two plates forming the sheath of the proboscis short and blunt, terminating in several short and two lateral long bristles; eyes narrowly oval, between them on each side

Lipoptera ibicis

* This may be *L. chalcomelæna*, Speis, found at Suakin, on Ibex and described in 1904, but without comparing the foot with this species it is not possible to say. A series in the British Museum from Ibex at Suakin has not been named.

are two groups of three equidistant thick spines, two ocelli on the basal region of the head. The thorax is narrowed in front, widening out posteriorly; the prothorax is a small plate extending across the thorax, openly wedge-shaped posteriorly. The mesothorax is the major area, and has numerous long thick needle-like spines; it has a distinct humeral swelling over the mesothoracic legs. In front, just behind the prothoracic legs, are two swellings, somewhat ragged or irregular apically, the remnants of the wings. The scutellum is uni-lobed with apparently six large black bristles on the posterior border. The whole of the thorax is fused into one piece. There is a distinct median and transverse suture. The abdomen is oval, deeply indented apically, the apical segments being enclosed in a pit formed by the prolongation of the anterior segments as two blunt processes on each side. The whole abdomen is covered with thick, black thorn-like spines, which are particularly long on the apices of the lateral lobes; the small imbedded apical segments have fine hair-like chætæ.

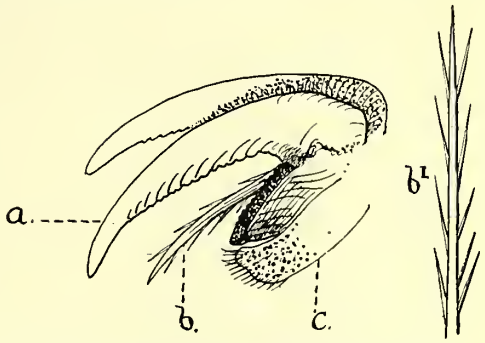


Fig. 46.—Ungues and bristle of hind leg of *Lipoptera ibicis* n. sp. *a* Ungues; *c* basal process; *b* and *b*1 bristle

Anterior legs with the short thick femora spinose; the tibiæ with a few fine hairs and a strong internal apical spine; basal tarsal segment spinose, the rest hirsute; ungues much curved, thick, the inner edge finely serrated with a large blunt basal process; the median process short and thick, with hairs on each side, terminating bluntly; mid legs very similar but shorter and thicker than the fore and the ungues thicker; in the hind legs the tibiæ are also spinose and the ventral tarsal spines are more pronounced than in the anterior legs, and the ungues are less curved, and the median plumose spine is acute

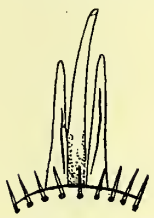


Fig. 47.—*Lipoptera ibicis* n. sp. Male genitalia

Length. 4 to 4·5 mm.

Male. Three ocelli present. Thorax narrower and smaller than in the female, the scutellum relatively larger and three lobed, and the spines on the thorax are fewer. Abdomen more rounded apically than in the female, and the external genitalia (Fig. 47) are prominent and consist of two chitinous lateral valves with the penis projecting between. The ungues are rather shorter and broader, and the median bristle is thin and acuminate with a few hair-like spines pointing forwards on each side.

Length. 4 mm.

Locality. The Sudan, Red Sea Province.

Observations. This Pupiparous dipteron was found by Dr. Crispin on an Ibex. It resembles *Melophagus* but does not belong to that genus on account of having ocelli.

The *Lipopteras** are winged at first but their wings are cast when they take up their abode on their host. In this species the areas to which the wings are attached are very marked.

The male has quite a different shaped process between the ungues to the female.

The description is drawn up from a male and female mounted in xylol balsam. It is closely related to *Lipoptera cervi*, Nitzsch, but differs from the specimen I have.

* The genus is usually called Lipoptena, but it should undoubtedly be Lipoptera as given by Siebold and Loew.

The Forest Flies (*Hippoboscidæ*) of the Sudan and Egypt

Hippoboscidæ

Four species of *Hippobosca* occur in the Sudan and Egypt, namely:—*Hippobosca equina*, Linn, *H. camelina*, Leach, *H. maculata*, Leach and *H. francilloni*, Leach.

These flies have all similar habits, being partially parasitic on animals. They have (at least, three of them) a very wide distribution.

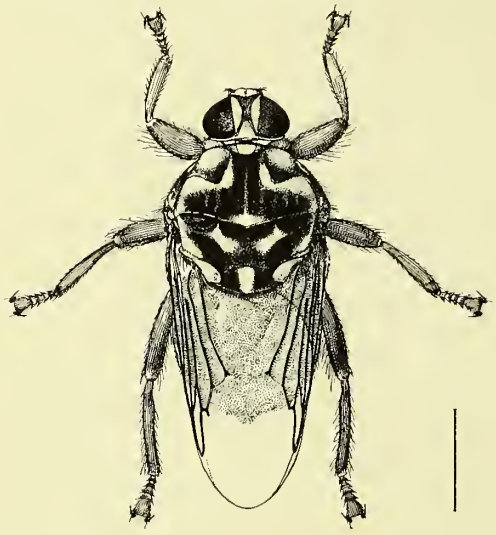


Fig. 48.—Hippobosca camelina, Leach
Arabia and Somaliland to Algeria
Body and legs reddish to dark brown; light markings of body, yellow

The species found most frequently on horses, asses and mules, *H. equina* occurs in Europe, Asia and Africa. It is also recorded from America by Loew and Lugger ("Silliman's Journal" and 2nd Report Minn., 1896, 143); but Aldrich states that it must be very rare there, as he has never seen it in any collection nor known of its capture by any entomologist. (Catal. N. Amer. Dipt., p., 653, 1905.) It also occurs in New Caledonia.

The Forest or Spider Flies are flattened, leathery and louse-like in appearance, and have their antennæ embedded in pits. Round or oval eyes; no ocelli, thus differing from *Lipoptera*. The abdomen is sack-like, and shows but faint traces of segmentation; and their short and stout spiny legs end in various appendages. They are all provided with a pair of ample wings during the whole of their life. The structure of the claws and other foot appendages as the pulvilli and feather-bristles is very marked. Some of the chief differences are shown in Figure 53.

Fig. 49
Scutellum of *H. equina*
Central portion pale yellow; sides brown or reddish brown

These parasitic diptera produce their young in the puparium stage. These puparia are passed out of the body of the female, often only a short time before the flies are ready to escape, and are of relatively large size compared to the dimensions of the adults.

The adults fly with short quick movements and hold to the hair of their host with great pertinacity.

Fig. 50
Puparium of *H. camelina*
Dark brown

They produce great irritation on the animals they invade. The mouth is in the form of a short, sharp sucking and piercing proboscis.

They are not only of importance as parasites, but they may be connected in some cases with the dissemination of Trypanosomiasis.

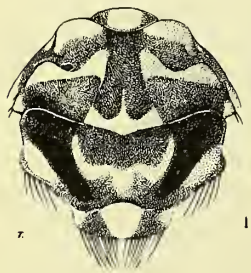
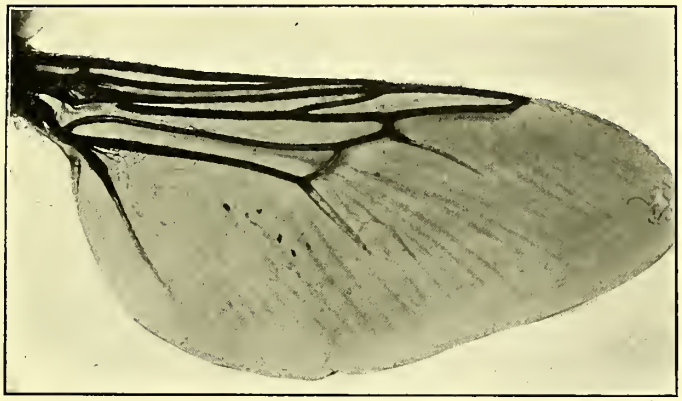


Fig. 52.—Hipp. maculata
thorax
Light markings pale yellow; remainder reddish-brown or brown.

The Spotted Forest Fly (*Hippobosca maculata*, Leach) occurs in Africa and India. I have received specimens from the West Coast, Egypt and the Sudan. It lives upon the horse, cattle, and will attack dogs. This species can be told by the scutellum being dark with three yellow spots, of which the median one is much the largest.

Fig. 51
Scutellum of *H. francilloni*
Pale yellow

1



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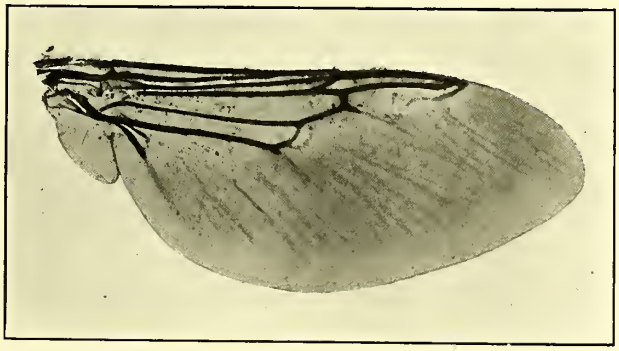


3

WINGS OF HIPPOBOSCIDÆ

1 Hippobosca francilloni. 2 H. camelina. 3 H. maculata.

(Magnified seven times.)

The Dog Spider Fly (*H. francilloni* Leach (=*canina* Rondani) is paler in color and smaller, and the scutellum is entirely pale yellow, moreover the wing-veins are rusty-red. Although it is essentially a canine pest, it may also be found on other animals. It occurs in Africa, India, Persia and in Southern Europe.

The Horse Forest Fly (*H. equina* L.) differs from the former in being darker, and in having the scutellum dark with a median pale patch (*vide* Fig. 49).

The Camel Forest Fly (*H. camelina*, Leach) is much larger than the preceding, and can also be distinguished by its scutellar markings.

This species has also been sent me from the West Coast (Senegambia).

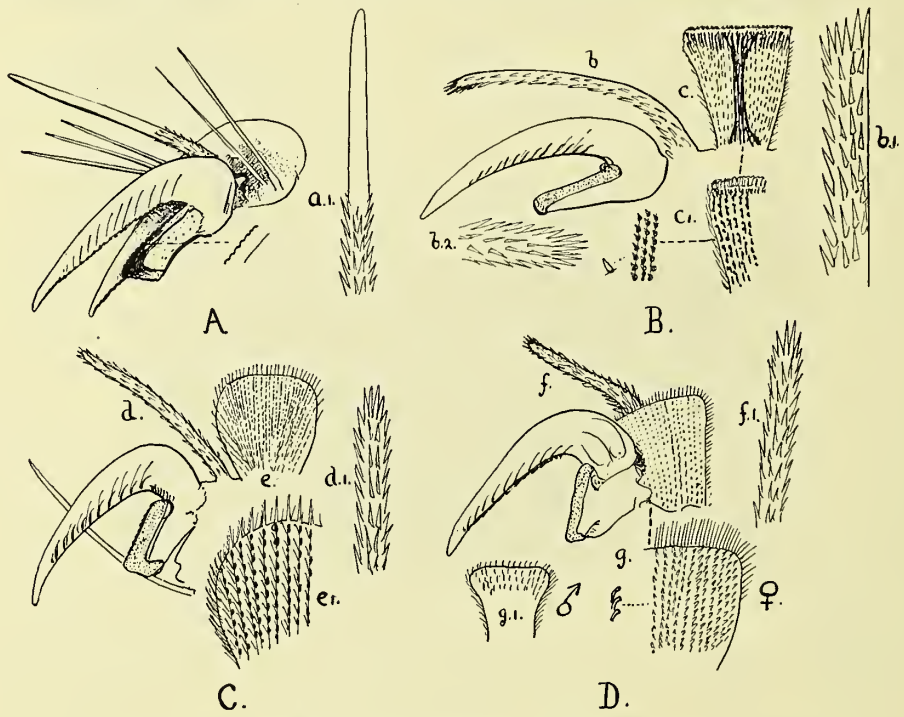


Fig. 53.—Ungues, pulvilli, etc., of *Hippoboscidæ*

A *Hippobosca camelina* ♀ ; *a*1 feather-bristle ; B *H. maculata* ♀ : *b*, *b*1 and b2 feather-bristle ; *c* and *c*1 pulvillus ; C *H. canina* ♀ ; *d* feather-bristle ; *e* and *e*1 pulvillus ; D *H. equina* ; *f* and *f*1 feather-bristle ; *g* pulvillus of ♀ ; *g*1 of ♂

The "feather-bristle" between the ungues in *H. camelina* is simple except at the base, not spiny as in the others, nor can I detect the pad-like pulvilli seen in the rest. The differences are very marked in the claws and central processes, as shown in the figures (A B C and D, Fig. 53).

The puparia of all these four species are placed amongst the hairs of the host. They are all very similar in form (Fig. 50). The color is deep brown when mature.

The markings on the scutellum are constant in all the Northern African specimens I have seen, but according to Austen they are variable, so cannot be relied on to separate the species. The figures of the wings and the feet will, however, suffice to separate them, and I have invariably been able to do so myself by the scutellar markings.

PART III

Vegetal Pests

Notes on some Vegetal Pests

Several interesting vegetal enemies have been collected by Dr. Balfour.

These include a new Cotton Pest—a small Halticid beetle—known as *Nisotra uniformis* of Jacoby.

A land or shield bug (*Lygæus militaris*, Fab.), which does much harm to dura, is also briefly reported, and a new dipterous enemy of melons, which is likely to prove a serious pest.

The Cotton Aphis of the Sudan will be described later. It proves to be the same as that found in Egypt, which as far as I can at present make out, is the *Aphis malvæ*, Koch, described many years ago.

A new enemy of the dura Aphis, a lady bird, is also added to the list of those mentioned in the previous report, namely, *Exochromus nigromaculatus*, Goeze.

Other Aphides have been received, but time has not allowed their being worked out.

At present we must acknowledge we know nothing of the Vegetal enemies of the Sudan, and these can only be properly worked out by a resident entomologist. My remarks are purely tentative.

The Melon Fruit Fly

(*Dacus*, sp.)

Dacus, sp.

Amongst the Diptera we find pests of every possible description. Those that attack fruit are the most difficult to cope with of all, and unfortunately they are easily distributed from country to country. Thus we find the Mediterranean Fruit Fly (*Ceratitis capitata* of Wiedermann) even in Australia where it is reported as doing much harm in Western Australia, etc.

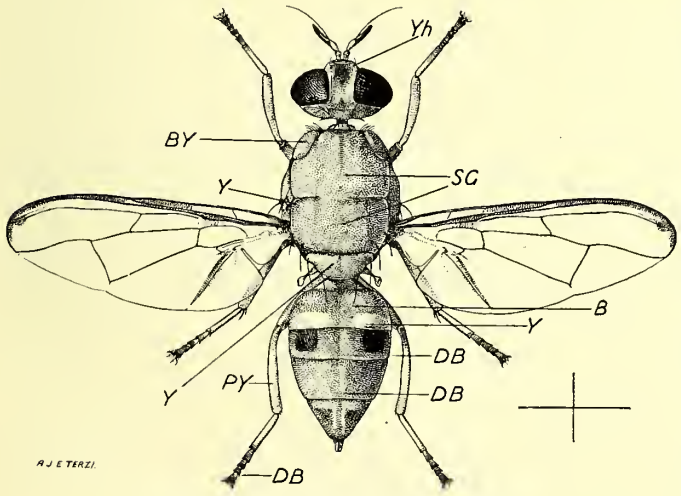


Fig. 54.—The Melon Fruit Fly (*Dacus*, sp.)
VH = yellowish; BY = bright yellow; SG = slaty grey; Y = yellow; B = brown; DB = deep brown; PV = pale yellow.

This pest has also been distributed to South Africa where it is the source of much loss to fruit growers in the Cape and Natal. This fruit fly attacks a great variety of fruits; apples, peaches, nectarines, guavas, persimmons, etc.

The Apple maggot (*Trypeta pomonella*, Walsh) is another which occurs in America where it does much harm.

The Mediterranean Fruit Fly is most destructive of all known species, for in Bermuda it entirely stopped the cultivation of peaches; in Malta it has been most harmful to oranges. For a time it did so much damage in the Azores that one-third of the oranges sent to London were found to

be unsound. The Queensland Fruit Fly (*Dacus tyroni*, Froggatt) also does much damage. Closely related to it is the Guava Fruit Fly (*Dacus pisidii*, Froggatt), which attacks Guavas in new Caledonia, and the South Sea Fruit Fly (*Trypeta musæ*, Froggatt) which is found in bananas from the New Hebrides. A well-known species, *Dacus ferrugineus*, attacks fruit in India.

Now we have to add another species attacking the melon in the Sudan.

The larvæ were sent to Dr. Balfour and to Mrs. Broun by Mr. Durrant, and the fly was bred out by them. Dr. Balfour sent me the laboratory specimens.

This insect comes very near to Froggatt's species, *Dacus tyroni*, the Queensland Maggot Fly, but it is quite distinct.

The genus *Dacus*, differs from *Ceratitis*, in having a less reticulate basal area to the wings, and from *Trypeta* in having the wings unadorned with dark areas over their

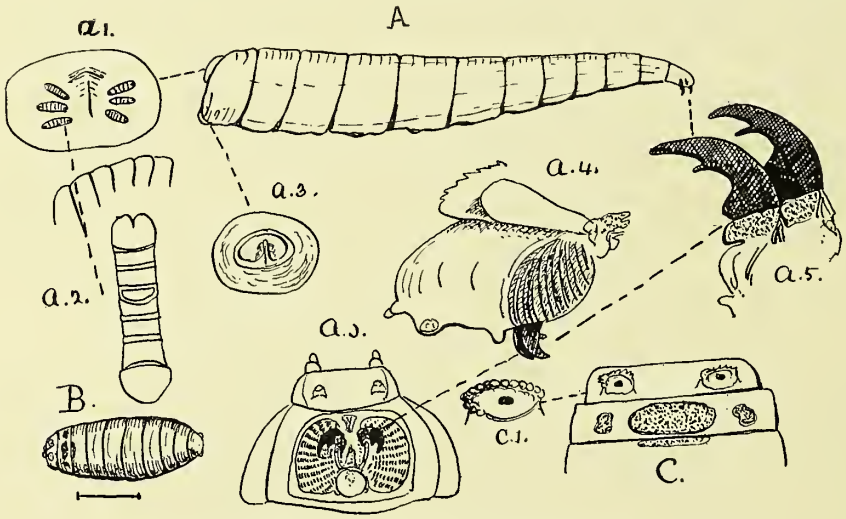


Fig. 55.—The Melon Fruit Fly (*Dacus* sp.)
A Larva (enlarged five times); *a*1 Spiracular plate; *a*2 further enlarged spiracle; *a*3 ventral process; *a*4 and *a*6 side view and front view of head; *a*5 mandibles; B puparium; C further enlarged posterior end of B

greater surface. The rot these maggots cause in fruit is very serious and according to Dr. Balfour the Sudan Melon Fly will probably prove a very serious enemy just as the others do in various parts of the world.

The Sudan melon fly is somewhat wasp-like in general appearance. The head is yellowish between the eyes, which are large and dark, there is a dark spot on the occiput and two oval black spots on the face below the antennæ, which are yellow with dark apex; the arista is simple. The thorax is slaty grey with minute deep brown specks and fine, pale, backwardly-directed short hairs, a bright nude yellow area at each shoulder, a yellow nude plate on each side in front of the base of each wing which passes as a narrow, wedge-shaped, area into the median transverse suture, the lower area of this spot is formed on the pleuræ, and there is a smaller one below it and another on the pleuræ just behind the wings; the scutellum is yellow and nude, and the metanotum deep slaty grey.

The abdomen is much contracted basally and acute apically, the basal segment is brown, the second has a yellow apical border, the remainder deep brown.

The legs are dull pale yellowish, somewhat transparent basally; the feet dark brown, the apex of femora and base of the tibiæ reddish-brown.

The transparent wings are dark brown along the costa, and there is a dark brown vein below, as shown in the figure (Fig. 54).

The chætotactic characters are very marked, there being four black bristles on the head four on the front of the thorax, two on each side of the median suture, one behind the root of the wings, and two long ones on the scutellum. The whole abdomen has fine, pale, backwardly-projecting bristle-like hairs.

Length. 10·5 mm.

The *larvæ* (Fig. 55, A) are creamy white, and 11 mm. long. They taper to a point at the head end and are bluntly truncated posteriorly. The mouth parts consist of two curved black mandibles (A5). The truncated apex carries two spiracles, as shown in the figure.

The puparium (B) is 6 mm. long, deep brown, and elongated oval in form.

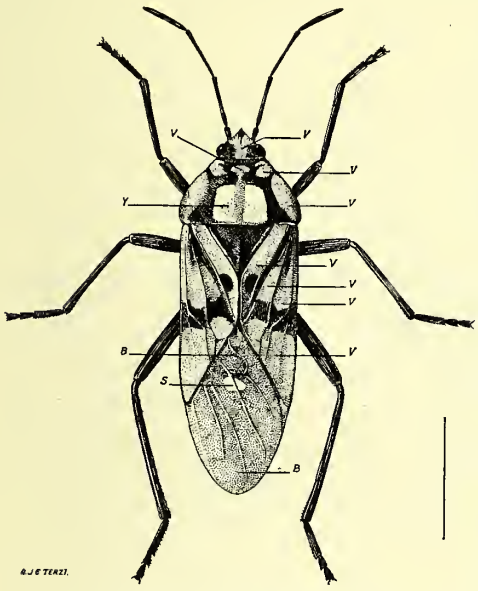


FIG. 56.—DURA PLANT BUG

Lighter markings of head and thorax, vermilion, except large median square spot on thorax, which is yellow; lighter parts of basal portion of wings vermilion; membranous apical portion brown, with median yellow spot; legs and dark markings on body black.

V vermilion; Y yellow; B brown; S yellowish spot

The *life-history* is probably as in the closely-related *D. tyroni* and other species. The female, by means of her pointed ovipositor, lays her eggs in the skin of the young melons.

The larvæ on hatching tunnel into the fruit, and so cause it to decay. When mature they leave the fruit and pupate around it, either beneath leaves or in the earth.

These pests are easily distributed in cases of fruit, when the larvæ are found pupating in the paper and other packing in the cases, and in the cases themselves.

Infested imported fruits showing any signs of fruit-fly attack should at once be condemned.

There can, of course, be no remedy for this kind of attack. At present all that can be done to protect fruit from fruit-fly attack is to net the fruit in fine muslin bags.

Various methods of attracting the flies with sweet and poisonous baits have proved of no avail. All diseased fruits should at once be burnt.

Froggatt and others have confused the genera *Dacus* and *Tephritis*, and erroneously described the Queensland Fruit Fly under the latter genus.

THE DURA PLANT BUG

(*Lygæus militaris*, Fabricius)

Lygæus militaris

This large brilliant Hemipteron has been found to do much damage to dura in the Sudan. The piercing apparatus punctures the plant and thus the insect draws out the sap.

Very many of these land bugs occur and often do much damage to cotton in Africa and America as well as to other plants, especially those belonging to the genera Oxycarenus and Dysdercus.

The same insect has been sent me by Mr. Willcocks from the Cairo district where it seems to feed upon a number of plants.

It is fairly widely distributed over Africa and is readily noticed owing to its red and metallic green hue. Nothing is known regarding its life-history, but it is probably similar to others of the same group. The larvæ are wingless and the pupæ have wing-buds.

Dura Aphis Enemies

Dura Aphis Enemies

Since the last report another Lady-bird Beetle has been found to feed upon *Aphis sorghi*, Theobald. It is known as *Exochnomus nigromaculatus*, Goeze. It is very similar in size to *Chilomenes vicina* Muls, figured in the last report (Plate c, 14).

In colour the head and thorax are bright shiny orange-yellow; the elytra are deep very shiny blackish-blue to almost black. The legs are orange-yellow. It also occurs in Lower Egypt in some numbers.

The larva of one of the Lace Wing Flies, *Chrysopidæ*, has also been sent, which was taken amongst a colony of this Aphis.

The Sudanese Cotton Flea Beetle

(*Nisotra uniformis*, Jacoby)

Nisotra uniformis

As far as I know this is the only Halticid yet recorded as attacking cotton. It is a small brown beetle, which has been identified by Jacoby as his species described from Sierra Leone. It probably occurs widely over Africa. No notes were sent with the insects except that they were damaging cotton.

A Hæmogregarine of Mammals*

H. Balfouri (Laveran)†

While carrying out work in connection with trypanosomiasis I have had occasion to make numerous examinations of the blood of the jerboa or desert rat (*Jaculus jaculus*, or *J. gordoni*, as I believe it has been renamed). (Fig. 57.) Mr. Butler, Director of the Game Preservation Department, whom I consulted, was not certain as to the species. It is worth noting that the hair pads of the hind feet are of a uniform brownish-white colour. In the first blood examined I was surprised to see that a large proportion of the red blood corpuscles harboured an unpigmented and non-motile parasite. In the stained specimen it was at once apparent that we were dealing with some kind of trophozoite. Sixty-two jerboas have up to the present been examined, and in all of them, with the exception of two adults and three very

Species of Jerboa

Fig. 57.—Jerboa or Desert Rat (About Two-Thirds Size)

young animals, one of which was newly born, this parasite has been found. The blood of two fœtal jerboas yielded a negative result. Specimens were sent to Professor Laveran, who at once declared the parasite to be a hæmogregarine, and has kindly informed me that the discovery is one of much interest.

The Appearance of the Parasite

The trophozoite in the fresh blood appears as a pale, hyaline, homogeneous body, slightly curved and with rounded ends (sausage-shaped), lying either apparently free or in the remains of a red blood corpuscle. Occasionally one finds it broader at one end than at the other, and the latter is then bent upon itself for a short distance. The erythrocyte may be represented only by a bow uniting the two poles of the parasite, just as it is sometimes seen

* Part of this paper appeared in the Journal of Tropical Medicine, and I am indebted to the Editors of that journal for their kind permission to reproduce it here.

† Laveran. Comptes rendus des seances de l'Acad. des Sciences. Vol. CXLI., p. 295, 1905.

in the case of malarial crescents. When the red cell is recognisable it is found to be of a very pale colour, indeed it looks as if no hæmoglobin were present in its spongioplasm. The free forms, I believe, owe their condition to a total destruction or absorption of the substance of the erythrocytes which once contained them. As stated, the parasite is non-pigmented and non-motile, and I have found it to be rather resistant, remaining to all appearance unchanged in sterile citrated blood for a period of seventy-two hours, both when kept at room temperature (about 36° C.) and at 22° C. It is to be noted, however, that it altered somewhat in its staining reactions. As a rule, it measures from 5·6 to 7 μ in length, and from 1·4 to 2·8 μ in breadth. The number present has been found to vary considerably. There may be six or seven, or even more present in each microscopic field (Leitz oc. 4, oil imm. $\frac{1}{12}$th), or only a few may be found in the whole blood smear.

Dimensions of parasite

Staining the Parasite

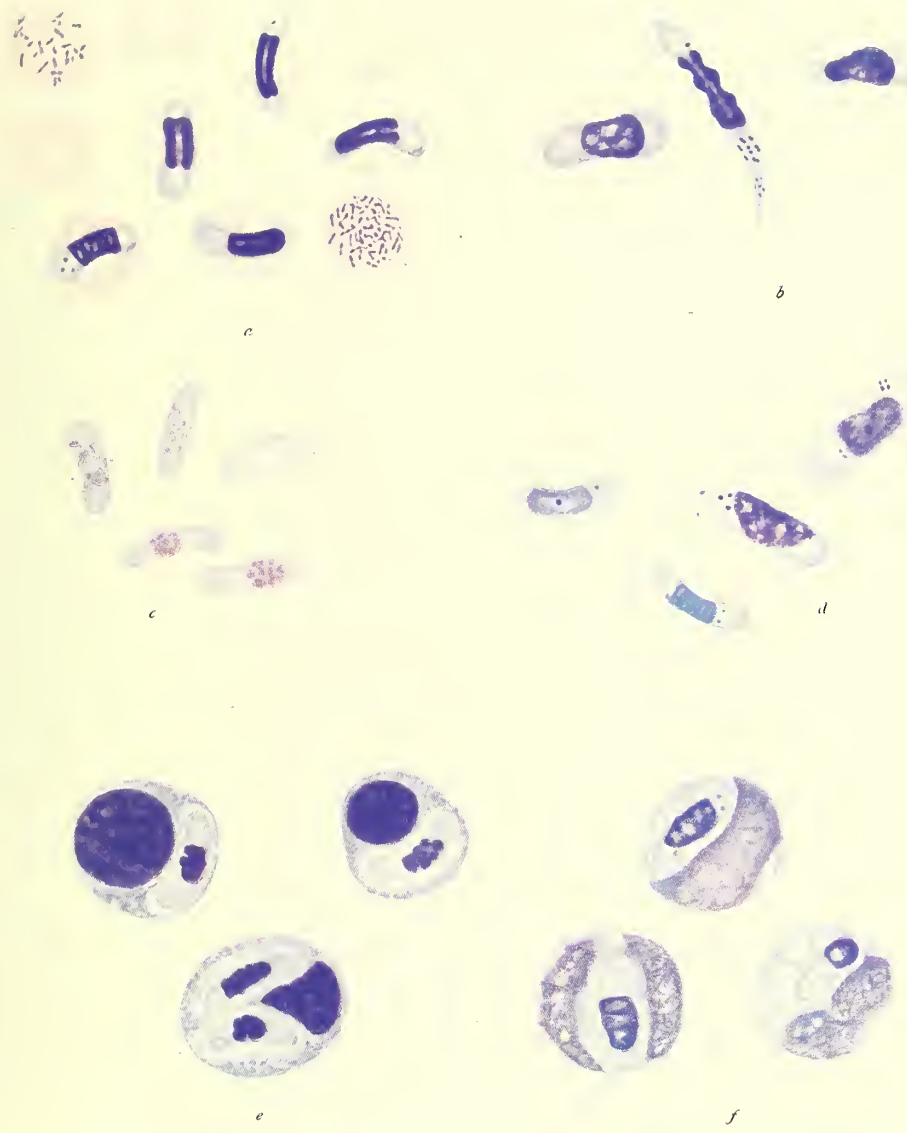
Appearance on staining

On staining by the Leishman-Romanowsky or the Giemsa method in exactly the same way as for malaria protozoa, the structure of the parasite becomes at once apparent and the shape, as described above, well defined. (Plate XI., Fig. *a*.) A large oval nucleus, constituting, as a rule, about one-third of the organism, is seen to be present, situated generally in the centre of the parasite and stretching right across it, so that there is a deep blue staining area (the nucleus) in the middle, and a faintly staining blue area with a rounded end on either side. Sometimes, but infrequently, forms with a tapering doubled-over end, *i.e.*, a "tail" flexed on the body, can be demonstrated. (Plate XI., Fig. *b*.) Occasionally but rarely, and then usually under special conditions, spherical chromatin dots may be found in one or other of these pale polar areas. In stained preparations one often notices that no vestige of the red blood corpuscle which originally harboured the parasite remains, but it is quite common to find parasites with portions of the red-staining erythrocyte adhering to them. All that may be present is a thin, red, curved line stretching from pole to pole across the slight concavity of the parasite. The corpuscles are often much deformed and take the eosin stain poorly. Sometimes, especially if the blood be citrated, the relation of the parasite to the blood cell which contains it is beautifully shown. A process of absorption of the cytoplasm of the red cell evidently goes on, and in a severe infection there must be a considerable destruction of erythrocytes. The animal host, however, does not seem to suffer in health. I have kept a jerboa with a considerable infection for three months in the laboratory, and it remained well and lively throughout the whole period. Three others died in captivity, exhibiting violent *ante-mortem* convulsions, and it is worth noting that these rodents do not stand handling well and must not be supplied with water.

In the peripheral blood it is customary to find all the parasites at or about the same stage of development. True, they differ somewhat in aspect. Thus it is not uncommon to find the nucleus situated at one pole, so that half the parasite stains a deep blue and the other half a very faint blue. Again, one end of the parasite may be pointed, so that the body is club-shaped. This is probably due to alteration during the preparation of the blood smears. In the heart's blood of a jerboa which died naturally I found two distinct forms, a large swollen variety (11·2 μ by 4·2 μ), in which the greatest increase had taken place in the light staining part of the protoplasm, and a form like those already described. It was very noticeable that the nuclei of the former, often of a triangular shape, stained a

Different forms

PLATE XI



RICHARD MUIR

HÆMOSPORIDIA OF THE JERBOA (*Jaculus gordoni*) AND THE RAT (*Mus decumanus*)

(*a*) Peripheral blood of jerboa showing endoglobular forms of *Hæmogregarina Balfouri*.
Two of the corpuscles exhibit what is either granular basophilia or the condition recently described in the erythrocytes of moles by Graham-Smith.
(*b*) Free forms of trophozoite, one being of the typical hæmogregarine shape with flexed tail. In the centre is a vermicule form from the peripheral blood.
(*c*) Free forms from a liver smear.
(*d*) Appearances presented in the heart's blood. Ordinary and swollen forms. Note the differences in staining reaction.
(*e*) Parasites apparently engulphed by the mononuclear leucocytes of the red bone-marrow.
(*f*) *Leucocytozoon muris* from peripheral blood of the Norway rat.
Note that one parasite lies between the halves of a divided nucleus.

Leishman Stain *All* × 1000 *diam.*

deep Romanowsky purple, and frequently did not stretch wholly across the parasite, and in the large pale-staining area three or four spherical chromatin dots were often to be observed. (Plate XI., Fig. *d*.)

Professor Laveran has seen this preparation and points out that such peculiarities in morphology frequently occur. He does not regard these as special sexual forms. At first I was inclined to consider the parasite as being allied to the halteridium of birds. I noted, however, that it was not pigmented, was not curved so much as the halteridium forms, and never exhibited the spore formation at either end as does *Halteridium danilewskyi*.

Endoglobular Hæmogregarine of this Class not Found Previously in the Red Corpuscles of Mammals

Apparently the first hæmogregarine found in mammals

As Professor Laveran kindly pointed out to me, and as indeed was soon apparent from a study of the literature, especially Professor Minchin's treatise* on the sporozoa, this parasite of the jerboa closely resembles the *Hæmogregarinidæ* of cold-blooded vertebrates. This fact is of extreme interest, as at the time I encountered it, I am unaware that any endoglobular parasite of this class had been described in the blood of mammals. Since then I have seen Christophers' description† of a very similar parasite which affects the red cells of the Indian Gerbil (*Gerbillus indicus*). Bentley‡ in 1905 produced a paper on a leucocytozoön of the dog in Assam, and it has been more fully described by James.§ Another leucocytozoön of mammals has been found by Patton in the palm squirrel of India, while I will shortly make reference to a similar parasite which I found in rats at Khartoum. The classification of this order of parasites given by Professor Minchin is as follows:—

Various leucocytozöa

"Order *Hæmosporidia* (Danilewsky).

"Sub-order 1. *Hæmosporea*.

"Genus i. *Lankesterella* (Labbé, 1899) for *Drepanidium* (Lankester). The hæmogregarine is not more than three-quarters the length of the blood corpuscle it inhabits.

"Genus ii. *Karyolysus* (Labbé, 1894). The hæmogregarine does not exceed the corpuscle in length.

"Genus iii. *Hæmogregarine* (Danilewsky, 1897) (syn. Danilewsky-Labbé, 1895).

"The body of the parasite when adult exceeds the corpuscle in length and is bent on itself within it in a characteristic manner like the letter V."

Now the parasite of the jerboa in question does slightly exceed the corpuscle in length, but is only slightly curved. It looks, as a rule, as if it had outgrown its corpuscle, and sometimes the remains of what has evidently been a distended and distorted corpuscle can be seen lying around it. The large swollen and bloated forms are much larger than the corpuscles which originally contained them and are found lying free. On several occasions, and especially in fresh preparations from the bone-marrow, I have noted forms slightly turned up at one end and looking like an incomplete letter V. (Plate XI., Fig. *b*.) As stated, I have not often been able to demonstrate this appearance in stained specimens. Christophers saw forms of his parasite in the act of leaving the red cells. I have never witnessed such exits. Like Christophers I have failed to find forms in the act of invading the erythrocytes, but like him I have often seen two forms lying in such close apposition as to suggest that fission had occurred. Each, however, possessed a separate capsule and doubtless the appearance was due merely to the infection of two neighbouring corpuscles.

True hæmogregarine form

* Minchin. A Treatise on Zoology (Lankester), 1903. Part I., Sporozoa.

† Scientific Memoirs by Officers of the Medical and Sanitary Depts. of the Gov. of India, 1905, No. 18.

‡ Brit. Med. Jour., May 6th, 1905, p. 888.

§ Scientific Memoirs, India, 1905, No. 14.

Laveran's classification,* in which the genus *Hæmogregarine* is made to include *Drepanidium* and *Karyolysus*, is more simple, but whichever be adopted, it would seem that this parasite is undoubtedly a hæmogregarine, and I had proposed to give it the provisional name of *H. jaculi*, though it is quite possible it may be found in other mammals. Professor Laveran, whose nomenclature takes precedence has, however, definitely named it *H. Balfouri*.† A study of its life-history has further indicated its relation to the *Hæmogregarinidæ*, for I have succeeded in finding two further stages, *i.e.* :—

(1) The free, motile vermicule form.

(2) The stage of schizonts in the form of cytocysts.

1. In three instances only have I found the free trophozoite. I discovered two such forms in the peripheral blood of a jerboa, which showed the endoglobular trophozoite in fair numbers and which had some injections of the serum of a water-buck in connection with trypanosome work; I came across a vermicule in the fresh heart's blood of another of the desert rats, and in the peripheral blood of a case with severe infection I noticed several of these forms. This free form is in length about three times the diameter of a red blood corpuscle, is pointed at both ends, and moves very slowly through the blood, progressing by a series of contractions of its cytoplasm, the so-called "euglenoid" movements. As a result constrictions appear in the body of the parasite, as many as three having been seen present at one time. These, so to speak, run along the body of the parasite, which thereafter assumes its usual cylindrical shape and glides steadily across the field, always proceeding in one direction and with the same end in front. It pauses for greater or longer periods, undergoing various alterations in shape. If it encounters a clump of red blood corpuscles it disappears amongst them, producing only a slight agitation amongst the erythrocytes, which it pushes out of its way. Granules are visible in the posterior part of the body. No flagellum has been seen nor anything to suggest the extrusion of a gelatinous thread, as occurs in the case of some of the gregarines. I was able to secure several stained preparations of this free trophozoite, the appearance of which further demonstrates its resemblance to a hæmogregarine. (Plate XI., Fig. *b*.)

The vermicule

Anteriorly there is a somewhat sharp-pointed area staining a light blue in which, close to the nucleus, a chromatin dot is visible. Following this clear area comes a very lengthy, oblong, deeply-stained nucleus. At one point it showed a constriction similar, no doubt, to those seen in the fresh preparation. It had been killed, fixed, and stained in the act of progression.

Behind the nucleus is a lengthy, light-staining area, terminating in a pointed extremity. This area stains a light blue with the Leishman stain and exhibits a cluster of chromatin dots, arranged in a somewhat rosette form immediately behind the nucleus. I noted a single central dot with six others arranged in a circle around it. A few similar dots, irregularly arranged, are also visible close to the posterior extremity.

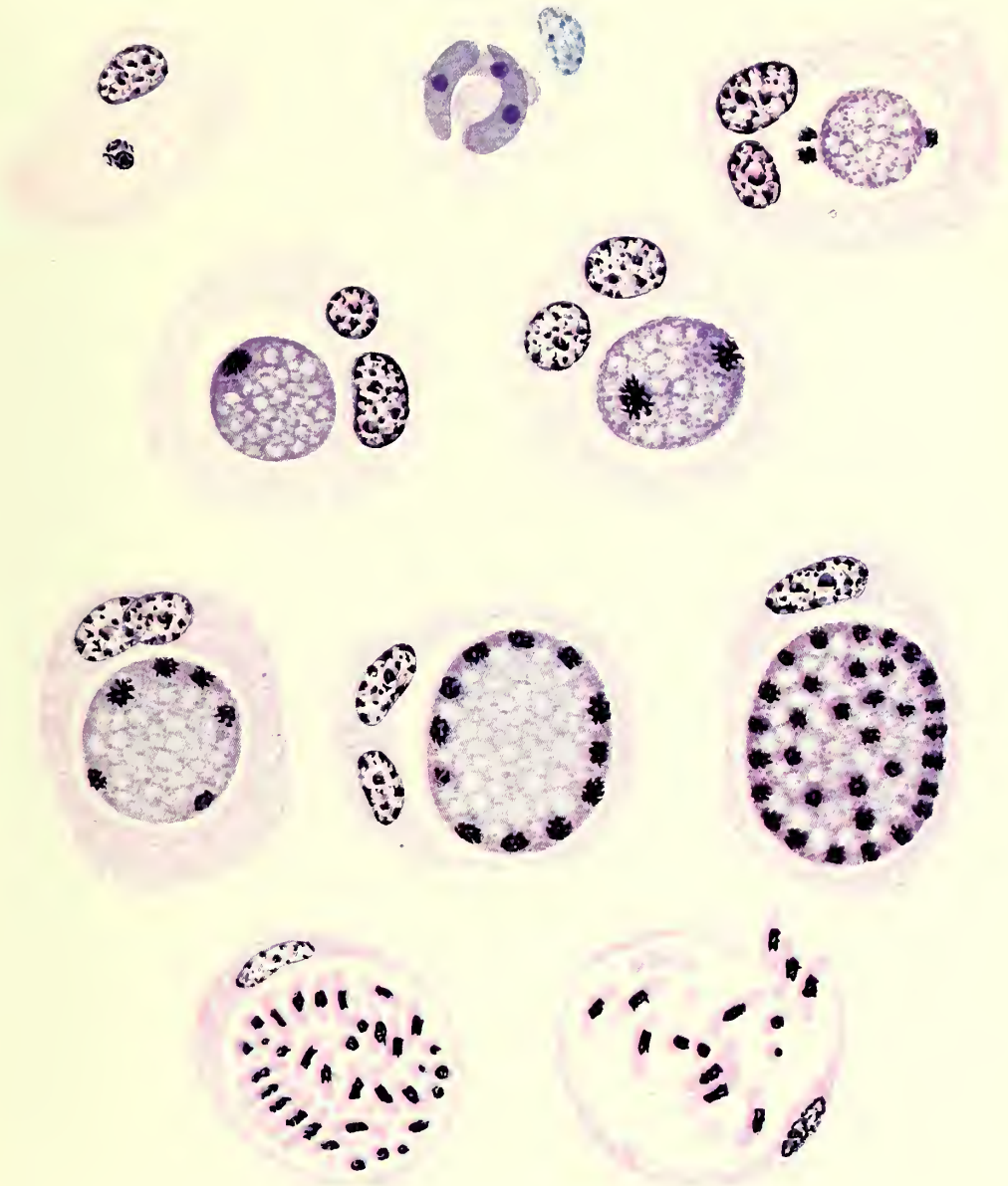
Measurements :—

Total length	15·5 μ
Length of nucleus	7 μ
Length of anterior light area	2·8 μ
Length of posterior light area	5·7 μ
Greatest breadth	2·8 μ

* C. R. Soc. Biol. (Paris), 1901, p. 798.

† C. R. Acad. Sciences, Vol. CXLI., p. 295, 1905.

PLATE XII



RICHARD MUIR

DEVELOPMENT OF *Hæmogregarina Balfouri* IN THE LIVER. CYCLE OF SCHIZOGONY. CYTOCYSTS AND MEROZOITES IN THE LIVER CELL

Giemsa Stain

The nucleus, it may be said, stretches completely across the body, entirely separating the anterior from the posterior moiety. The broadest part of the parasite is towards the posterior end of the nucleus.

2. In most cases a third stage can be readily demonstrated. This is chiefly seen in the liver and kidney, organs where the circulation is slow, and will probably be found also in the bone-marrow and brain. Indeed, some smears of the bone-marrow have shown what were probably empty cytocysts. In thick smears from the liver and kidney well-defined cysts are found, the walls of which are apparently formed by the remains of cells of these organs which have been destroyed by the parasitic growth.

Cytocysts and merozoites

These cysts vary much in size. The largest I have noted occurred in a liver smear and measured 39·6 μ by 33·6 μ. A common dimension appears to be about 22·4 μ by 16·8 μ, but many smaller cysts occur.

Stage of schizogony

It is usual to find some of these cytocysts empty, or at the most containing a little residual protoplasm, but a certain proportion are found to contain merozoites, readily recognisable by their shape and nuclei, and somewhat resembling the trophozoite stage in the blood. Their nuclei, however, are comparatively small, and in many cases the merozoite appears to be longer and more pointed at the ends than the endoglobular trophozoite. Early schizont forms also occur, in which the protoplasm contained within the cyst wall has not become differentiated and stains more or less uniformly. Sometimes darker-staining portions indicate the future nuclei of the merozoites. When complete division has taken place some residual protoplasm remains behind, and the whole condition is very like that which has been described by Labbé* in the case of *Karyolysus lacertarum*. Sections of the liver stained by the Giemsa method show all stages of the schizonts. Mitosis of the nuclei and the formation of daughter nuclei are well seen.

Resemblance to the Coccidia

Appearances very like those presented during the schizogony of some of the Coccidia, notably *Adelea ovata*, are exhibited and the whole condition from the invasion of the liver cell to the bursting of the cyst and the freeing of its contents can be traced.

By what channel the hepatic cell is invaded has not as yet been determined, but it is probably through the capillaries. *(Vide infra.)*

Liver sections

The interesting appearances presented by these liver sections (Plate XII.), which were kindly prepared for me by Mr. Richard Muir, of the Pathological Department, University of Edinburgh, from embedded tissue which I took home with me, have been further studied in sections prepared and stained in the laboratories. These sections were stained by hæmatoxylin and eosin, by the Giemsa and Leishman methods, and by Heidenhain's iron-hæmatoxylin process. Ordinary free forms of the hæmogregarine such as are met with in the peripheral blood could be seen, and on one occasion I found such a form lying in close apposition to the nucleus of the endothelial cell of a capillary, which observation probably indicates the channel of invasion. As regards development the earliest appearance seen is that of a large, pale-pink (Giemsa or Leishman stain), body of an oblong or nearly spherical shape occupying a cavity which has been formed in a liver cell. The body varies in size. One which was measured gave the following dimensions: Greatest length, 12 μ; greatest breadth, *i.e.*, at nucleus 7·5 μ. Another measured 12 μ × 6 μ. The nuclei of these bodies are small and spherical, centrally-placed, and stain chromatin red. They are found to be undergoing mitosis. I believe these bodies to be trophozoites which have become enlarged

* Arch. Zool. Exp. et Gén. (3) ii. 1894.

and swollen prior to division. As a result of its increase in size within the hepatic cell, a small cyst is formed at the expense of the substance of the cell, the nucleus of which gets pushed to one side. The wall of this cyst, formed from the compressed cell protoplasm, becomes very well defined, and as a rule a space is left between the body and the cyst wall. What I believe to be the next stage is evidenced by the presence of one or more curved bodies in these small cysts, together with what I take to be the remains of the original body from which these curved forms have been derived by a process of nuclear division. (Plate XII.)

These curved forms rather resemble the trophozoites of the blood, but they differ from these latter in having small spherical nuclei, often seen undergoing mitosis, and in the fact that as a rule they are more curved and somewhat larger. They were found to measure from 9 μ to 10·5 μ in length by 3 μ in breadth. They are often somewhat club-shaped and their cytoplasm stains a bluish-purple and their nuclei take on a chromatin red colour. What I think represents the residual cytoplasm of the mother body is usually seen as a pale pink, non-nucleated spherical mass lying in the concavity of one of these curved forms. (Plate XII.) It rather suggests a so-called polar body and is not seen when more than three of the curved forms exist in the cyst. When several of the curved forms are present one finds that they are lying at different levels. Thus only two may be visible at first, but on focussing either up or down a third comes into view lying, it may be, across the other two. Division has evidently taken place in different planes.

The stage which follows is that of the undifferentiated schizont. (Plate XII.) A more or less spherical mass of protoplasm, staining a dark blue colour, is found lying in the cyst, which has become larger. Cysts at this stage, often measure 12 μ in diameter. The contained schizont mass varies in size and is often about 8 μ across. Differentiation takes place, evidenced by the appearance of nuclei which are seen studded, so to speak, all over the schizont mass or arranged round its periphery. (Plate XII.) When the latter is the case a very pretty appearance is exhibited. The cyst is found to have undergone further enlargement, common measurements at this stage being 22·5 μ to 25·5 μ in greatest diameter. Sometimes no space exists between the substance of the hepatic cell and the dividing mass. In such cases the cyst wall is ill-defined. As a rule, however, both unstained space and wall are well marked, while the nucleus of the hepatic cell has either wholly vanished or has become much flattened out and in consequence has taken on an oblong or spindle shape. Very little of the liver cell is left, and in the next stage, that of division resulting in the formation of the merozoites, it is common to find it represented merely by the cyst wall which is often thicker in some parts than in others.

The final division is seen at several different stages, and it appears to be complete, no residual protoplasm being left. The merozoites all present the same appearance and are much the same size. (Plate XII.) Those which I have measured were about 6 μ in length by 1·5 μ in breadth. They stain a pale red or pink and their nuclei take on an intense chromatin red colour with Giemsa or Leishman stain. They are very slightly, if at all, curved and are found crowded together, lying at different levels and in divers directions, or arranged symmetrically round the periphery of a portion of the schizont mass which has not yet proceeded to division.

The final stage is evidenced by the bursting of the cyst and the freeing of the merozoites which doubtless pass into the blood stream and invade the red blood corpuscles, thus starting once more the cycle of schizogony. (Plate XII.) Empty and shrunken cysts can be seen

in the liver sections, as can merozoites lying free and easily distinguishable by their colour, size and nuclei. (Plate XII.)

Laveran * has pointed out that the schizont stage of hæmogregarines in reptiles is passed in the liver, and Labbé has given much attention to this subject. As indicated, I have not yet been able to decide whether dimorphism occurs, and if micro- and macromerozoites can be distinguished.

Before seeing the liver sections I was under the impression that the non-sexual cycle was probably as follows: The trophozoite is set free from the erythrocyte as the travelling vermicule, which eventually penetrates a cell of the liver or kidney, and gives rise to schizonts in the form of cytocysts. In these the merozoites are formed which, after certain changes, eventually escape into the blood stream, invade red blood corpuscles and so restart the cycle of schizogony.

So far, however, one has not been able to see anything like the travelling vermicule in the liver sections. One jerboa was chloroformed, a post-mortem performed immediately, and samples of the liver blood taken by means of a hypodermic syringe. This procedure, however, yielded no fresh information. Only the ordinary trophozoites were found. Squash preparations of the liver were made, but failed to aid one. The cytocysts and merozoites were clearly seen, but no preliminary stage could be observed, and no changes took place under the microscope. The form invading the hepatic cells looks like the trophozoite of the peripheral blood, or, at the most, one of the swollen forms already mentioned. Is it, then, possible that the travelling vermicule plays no part in this cycle? Such is possibly the case, or again, as Labbé asserts, for *Lankesterella* and *Karyolysus*, an isogamic conjugation may take place between two of these free forms, and it may be the zygote so formed which can be seen penetrating the liver cells. Many, however, disbelieve Labbé's conclusions, which have not been confirmed by the observations of Hintze† on *Lankesterella*, so possibly the freed trophozoite directly invades the liver cell and becomes the schizont, while the free vermicule is intended to play a part in an extracorporeal sexual cycle. This leads us to consider the habits of the jerboa and the parasites which it harbours.

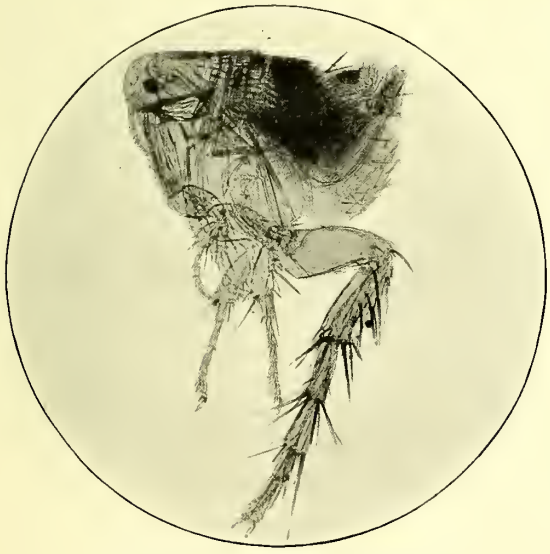


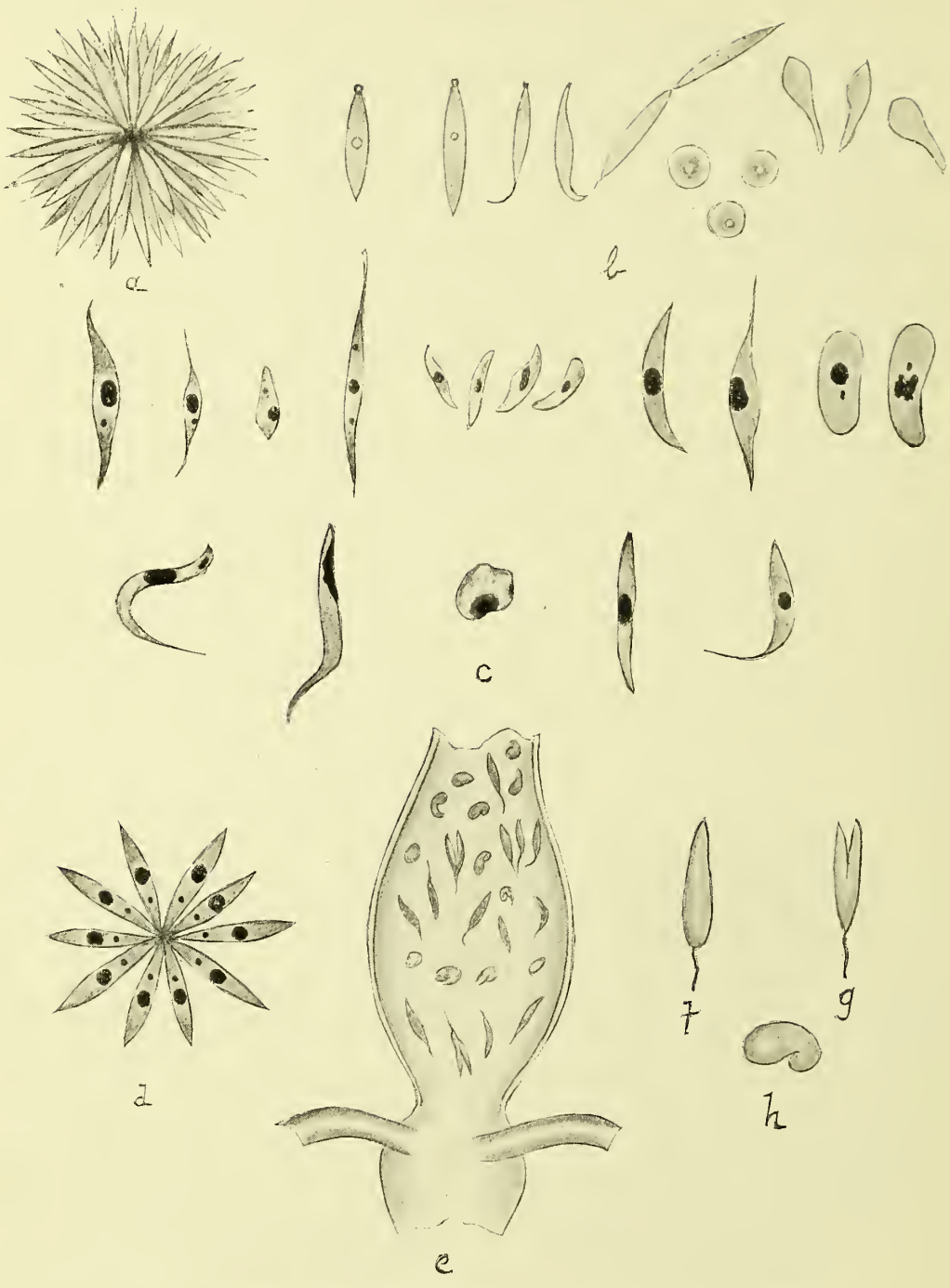
Fig. 58.—Flea of Jerboa ♂ (× 35 diam.)

The rodent is a nocturnal animal, living in holes in the desert, remaining invisible throughout the day, but found hopping about in the evening and on moonlight nights. It exists far from any water, which it does not seem to require, and its food probably consists of the minute seeds of the small plants which contrive to exist in sandy wastes. The animal is easily caught in traps baited with millet.

Nocturnal habits of jerboa

Both fleas and mites are found on the jerboa. The species of *Siphanoptera* present is

* C. R. Soc. Biol., Paris (10) v. [i.] 1893 and (11) i. [li.] 1899.
† Zool. Jahrb. Abth. f. Anat. xv. 4. 1902.



FLAGELLATED AND VERMICULAR PARASITES OF THE FLEA (*Pulex cleopatræ*). ROTHS. *(Greatly Enlarged)*
(Drawn by Richard Muir from original sketches by A. B.)

(*a*) Colonie radiée ; unstained.
(*b*) Vermicule and amœbulæ forms ; unstained.
(*c*) Vermicule, flagellated and other forms ; *Leishman stain.*
(*d*) Colonie radiée ; *Leishman stain.*
(*e*) Posterior part of mid-gut showing amœbulæ becoming transformed into flagellated forms. Some of the latter are in process of division by fission.
(*f*) An unstained flagellated form.
(*g*) An unstained, dividing, flagellated form.
(*h*) An unstained amœbula as seen in the posterior portion of the mid-gut. It approximates to the typical form of a Hæmogregarine.

usually *Pulex cleopatræ* (*Rothschild*),* and I have dissected and examined the internal organs of engorged fleas taken from infected animals. At first my observations were limited to the stomach of the flea in which at first I only found the trophozoites which had been sucked up with the peripheral blood, and which I was able to stain in smear preparations. Some blood containing endoglobular trophozoites was placed in the acid citrate solution devised by Rogers† to simulate the conditions present in an insect's stomach. Though kept in this medium for over 48 hours at room temperature, no change took place in the parasites, save that their cytoplasm became more granular.

Possible stage in flea

Later, on two occasions, in the Malpighian tubes, I found bodies identical in appearance with the free trophozoites of the parasite. In one tube, only a few were present, the other contained a large number. It was quite easy to distinguish them and they appeared to have undergone no change beyond a liberation from the erythrocytes which originally contained them. I do not think they indicated any stage in a developmental cycle, but believe they were merely undergoing a process of elimination. The flea may have been a male. The sex was not noted.

Probable Cycle of Development in the Flea

At a later date a more systematic examination of fleas by means of fresh dissections and stained paraffin sections was conducted and is still in progress. The results, so far, have been most interesting as not only has a true cycle of development apparently been found, but bodies resembling very closely those described by Schaudinn‡ in the supposed development of *Halteridium danilewskyi* in *Culex pipiens* have been encountered. A very brief mention of what has been noted must suffice.

Results of flea dissections

A flea ♀ was dissected thirty hours after removal from its infected host. After pressure had been made on the cover glass there were found lying free, close to the termination of the rectum, spherical forms, vermicules, rosettes of vermicules and tiny flagellates. It looked as though these had been squeezed out of the alimentary tract of the flea.

Forms of flea parasite

(*a*) Spherical (gregarine) forms. These at first suggested altered trophozoites, were small and indefinitely granular. They were not numerous. (Plate XIII., Fig. *b*.)

(*b*) Vermicules. These were small, contained refractile spots, and in several instances showed at one extremity an accumulation of what looked like pigment in active motion. This was cut off from the body of the vermicule by a slight constriction, and the whole appearance markedly resembled certain of Schaudinn's diagrams. (Plate XIII., Fig. *b*.)

Some of the vermicules were united end to end, and some possessed short flagella. Many were in active vibratile motion. Forms somewhat swollen at one end (club-shaped) were also noticed. (Plate XIII., Fig. *b*.)

(*c*) Rosettes. These were very remarkable consisting as they did of clumps of vermicules in a state of very active vibratile motion. They varied much in size and in the number of vermicules which formed them, and resembled nothing so much as crowded clusters of tiny petals. It is possible that these "vermicules" were really flagellated forms, the flagella being very minute. (Plate XIII., Fig. *a*.)

* The Hon. N. Charles Rothschild, F.Z.S., has kindly identified this and other species of fleas which have been sent him from the Laboratories.

† "Lancet," June, 3rd, 1905.

‡ Generations und Wirtwechsel bei Trypanosoma und Spirochæte. Arbeit aus dem Kaiserlichen Gesundheitsamte. Band XX., Heft 3, 1904. Trans. *Brit. Med. Journ.*, London, 1905, Feb. 25th, p. 422.

(*d*) Flagellates. These bodies were of a distinct trypanosome or trypanoplasma type. Flagella either at one or both ends, were clearly visible, and they were in a state of very active vibratile motion, though they did not seem to possess much motion of translation. (Plate XIII., Fig. *b*.)

All the forms were watched for several hours and no changes were noted, save that some of the vermicules became motionless and others appeared to change into typical flagellated forms.

Fig. 59.—Colonie radiée (× 2000 diam.)

Stained preparations were secured of all these forms, and a rosette of vermicules is shown in Plate XIII., Fig. *d*, and in Fig. 59. These were obtained from a flea, dissected sixteen hours after feeding, in which spherical forms and vermicules, either free or in small rosettes, were the only forms found. It will be noted that the blepharoplasts are large and are towards the centre of the rosette, *i.e.*, towards what are probably the anterior extremities of the vermicules.

These vermicules measured 7·5 μ, to 9 μ, in length.

The stained forms from Flea 1, Plate XIII., Fig. *c*, gave the following measurements:

Measurements of vermicules and flagellates

Vermicules—7·5 μ, 9 μ, and 12 μ in length.
1·5 μ, to 2 μ in breadth at nuclei.

Flagellates—Total length .. .. 10·5 μ to 11·5 μ.
Length of flagella .. .. 3 μ to 4·5 μ.

Some of the trypanoplasma forms were found to contain two small spherical chromatin masses in addition to the nucleus or karyosome. These may represent the "diplosome" of Prowazek.* (Plate XIII., Fig. *c*.) In neither the vermicules nor the flagellated forms was there any indication of an undulating membrane.

The spherical forms possessed well-marked nuclei, and there were also seen what appeared to be intermediate forms between them and the vermicules in which blepharoplasts had developed. (Plate XIII., Fig. *c*.)

[Ordinary unchanged trophozoites of the *Hæmogregarine* and a few large vermicules like those found in the peripheral blood of the jerboa were also met with in the stained preparation. They had not been observed in the fresh dissection.]

Possible explanations of appearances observed

It seemed to me that these appearances might represent one of three things:

1. A special parasite of the flea of the nature of *Herpetomonas* or *Crithidia*.

2. A development of trypanosomes in the flea which, though taken from a jerboa, might possibly have fed on a gerbil with trypanosomiasis, but *vide* "3."

3. A cycle of development of the hæmogregarine of jerboas, somewhat analagous to that described by Schaudinn for *Halteriduim danilewskyi* in *Culex pipiens*. That the last was the correct explanation I at first thought probable. Supposition 2 was put wholly out of account, as several fleas in which these appearances were found could not have fed on a trypanosome-infected animal, while in one flea dissected twenty-four hours after removal from its host, I observed in the posterior part of the mid-gut amœboid-looking forms, some

* Arb. aus d. Kais. Gesundheitsamte XX., 1904.

of which in size and shape very closely resembled hæmogregarine forms. (Plate XIII.; Figs. *c* and *h*.) These were seen to change into flagellated forms which were attached by their short flagella to the epithelium lining the gut, and kept lashing from side to side in active motion. Some of them were watched undergoing longitudinal division while still attached to the gut. (Plate XIII.; Figs. *c* and *g*.) It is worthy of note that this division began at the end opposite the flagellum, and therefore presumably could not have been dependant on a binary division of the micro-nucleus, unless, and this is interesting, these forms were identical with some of the stained forms to which Fig. *c* refers. There at least one parasite will be seen resembling a trypanosome in all but the absence of an undulating membrane, for, as will be noted, the micro-nucleus is at the opposite end from the flagellum.

Total length of living vermicules ..	12 μ.
Breadth	2 μ at broadest, *i.e.*, anterior part.
Length of flagella	3 μ.
Amœboid forms .. .. about	6 μ in either diameter.

It was curious that at first I only found these various forms in female fleas which had been fed on infected jerboas. This, together with the descriptions given by Schaudinn, naturally led one to think that the third supposition was correct. Further investigations, however, have served to confute this idea, for I soon began to find these appearances in male fleas fed in the same manner, and finally, my assistant, Mr. Friedrichs, discovered similar forms in fleas taken from freshly-caught gerbils with normal blood. It was, therefore, apparent that the first supposition was the correct one, *i.e.*, that these bodies were in reality parasites of the flea itself. That they belong to the family known as the *Crithidia** I now have little doubt, especially after reading the interesting papers by Ross, on the intestinal parasites of mosquitoes.†

The correct solution

It is evident that the rosette forms are the *colonies radiées*, the spherical amœboid forms are the *amœbulæ*, and the flagellates are the *flagellulæ* which he describes, and which Léger termed "formes monadiniennes." It seems to me that these results tend to support his contentions, and those of Novy and McNeal,‡ against Schaudinn's work, and are therefore of considerable interest. Sections of fleas show clusters of the parasites, which are easily recognisable. Apparently, judging from Birt's§ list, these protozoa have not been previously found in fleas. Further proof has been obtained by the discovery in one female flea of what seems to be the real cycle of development of the *Hæmogregarine*, which proves to be precisely similar to that described by Christophers for *Hæmogregarina gerbilli* in the louse.

It was some time before I could obtain Christophers' paper. I then found his very interesting account of the cycle passed by that parasite in *Hæmatopinus Stephensi*.¶ This is very briefly as follows:—A first stage of free vermicules is found in the mid-gut, intestine, and occasionally elsewhere. This is succeeded by the formation of large cysts which are found lying free in the body cavity. These large cysts contain numerous small oval cysts, and these in their turn contain crescentic bodies (sausage-shaped when liberated). These bodies Christophers believes to be of the nature of sporozoites. He records a curious observation to the effect that contact with fresh blood plasma apparently caused

* Léger and Dubosq. Comp. rend. Cong. de Montauban, 1902. Léger. Comp rend. Soc. de Biol., 1902. Léger. Comp. rend, dcl'Acad. des Sciences, 7/4/02.

† *Journ. of Hygiene*, Cambridge, January and April, 1906.

‡ *Journ. Infect. Diseases*. Chicago, March, 1905.

§ *Journ. R.A.M.C.*, June, 1906.

¶ Thompson Yates and Johnston Laboratorics Report Vol. VII. (new series), Part I., Feb. 1906.

some of these crescent bodies to become transformed into large vermicules which, after being kept in the incubator at 37° C., were found to possess the curious property of rotating the red cells by means of their narrow extremities. Christophers regards this behaviour as very significant of the probable method of infection. Up to date I do not know that he has added anything further to these observations, which, as he points out, are of special interest, "since although the transmission of many protozoa by biting insects has been demonstrated by experiment, the only instance, of which we have actual knowledge of the stages gone through in the carrier, is that relating to the developmental stages of certain parasites in the mosquito."

Developmental cysts in flea

In the case of the hæmogregarine of jerboas and the flea it was found that the large cyst had ruptured, as evidenced by its burst and shrunken wall. Certain parts of the field were crowded with the smaller "daughter" cysts, most of which were nearly spherical in shape and varied in size, measuring from 16·4 μ to 25·6 μ in their greatest diameters. Each possessed a well-marked wall with a double outline, and they contained slightly curved sporozoites with rounded ends. These latter measured about 16 μ in length by 4·20 μ in breadth and the whole appearance was, as I have indicated, precisely similar to the small cysts described by Christophers. It was evident that a great multiplication had taken place, the first stage of which is no doubt the production of travelling vermicules. I kept these cysts under observation for 24 hours but no marked change took place in them or in any of the freed sporozoites. At the end of that time a stained preparation was made, but the sporozoites were found to have degenerated in the citrate solution and took the colour badly. They were distinctly of a sausage shape. The cysts also did not stain well and it is unfortunate that a fresh preparation could not be obtained for staining. My observations have not proceeded beyond this point. It is curious that though a large number of fleas were examined these appearances have only been found in one case. It is possible the flea in question was not *P. cleopatræ* but belonged to another species which alone may be capable of acting as host. This, and the further development, are questions requiring elucidation and which I hope may ere long be settled.

Fig. 60.—Mite of Jerboa (× 42 diam.)

I have also examined the small mites which infest jerboas. They are never very numerous on the rats, but, as a rule, three or four can be obtained from each animal by careful search. I found they belonged to the genus *Dermanyssus*, and believe them to be identical with *D. gallinæ*, which, though primarily a parasite of fowls, is known to attack mammals and even man. In the female the cheliceræ were seen to be in the form of long thin stylets (Fig. 60). I proceeded to dissect these mites and their larvæ, no very easy task, at least when their diverticula are gorged with blood. If a mite is dissected immediately after it has been feeding on its infected host the blood which has been sucked up presents no differences from that in the jerboa. In other words, the trophozoites, either free or still contained in the erythrocytes are to be seen. If such blood be citrated and kept for twenty-four

hours or more, either at room temperature or in the incubator at 37° C., no change results.

If, however, some time elapses, say twenty-four hours, before the mite be examined, numerous vermicule forms are sometimes found in fairly active motion, together with many unchanged trophozoites. These vermicules bend themselves from side to side and also progress amongst the altered or disintegrated blood corpuscles. They do not exhibit the "euglenoid" movements shown so markedly by the free vermicules found in the jerboa, but merely glide about. On staining it was noticeable that their cytoplasm was quite free from chromatin granules, though it stained a pale blue as in the "jerboa" vermicules. This agrees with the characters of the vermicules from the louse described by Christophers. On the other hand, from measurements I have made, I find these "mite" vermicules just about the same size as the "jerboa" vermicules, whereas Christophers found the "louse" vermicules distinctly larger than those present in the gerbil. I have now examined a considerable number of mites both gorged and ungorged, and at various times after feeding, and have carried out a few experiments similar to those conducted by Christophers with lice, but I have not so far been able to absolutely satisfy myself that cyst formation occurs. One is apt to be deceived, as large cysts, looking to the naked eye like minute white spheres, are sometimes obtained from the mites, and on examination these cysts are seen to be packed with spherical bodies. The latter, however, appear undoubtedly to be some form of fat cell. They are highly refractile, somewhat resemble large oil globules, and their contents dissolve on the addition of ether. Once, and once only, in a case where no large cyst was seen, I found small bodies like cysts and apparently containing crescent-shaped forms, the whole appearance being rather like Fig. 16 in Christophers' monograph, which illustrates zygotes containing sporozoites. There was, however, nothing so definite as the well-marked cysts found in the flea, and I am not inclined to lay any stress on this observation. I kept the slide of citrated blood from the mite for sixteen hours in the hot incubator at 37° C., and thereafter could not find any of these cysts (?) in the preparation. Captain Cummins, to whom I showed them, agreed that they resembled Christophers' illustration.

Possible stage in mites.

A fact of interest is that, in one case on examining comparatively fresh citrated blood expressed from a mite which had fed five hours before on a jerboa with a moderate infection, I noticed several large vermicules dragging small clumps of red cells after them, there being a distinct interval, possibly bridged by an invisible gelatinous thread, between the narrow extremity of the vermicules and the corpuscles. Continuing to watch one of these vermicules I saw it start curious rotatory movements exactly like those Christophers describes in the case of the vermicules derived (?) from the sausage-shaped bodies in the small cysts found in the louse. I watched it for quite a long time. As a rule it was the parasite itself which rotated, using the red cells as a fixed point on which to turn. After a time motion ceased and the vermicule changed in shape, becoming swollen at one end. Many ordinary free trophozoites were also present in this blood in which no vermicules could be seen after it had been kept all night at 37° C. These results, though by no means conclusive, are somewhat suggestive, and I believe the mite may yet be found also to serve the part of an intermediate host. Latterly I have been unfortunate in not being able to secure jerboas with large infections of the hæmogregarine. Given a good case, it is possible that one might find the same cystic stage as Christophers has described for

H. gerbilli in the louse *(Hæmatopinus Stephensi)*, and which I have seen in the flea in the case of *H. Balfouri*.

As the jerboa is nocturnal I thought it well to chloroform one during the night, and at once examine its blood and organs. I failed to find the vermicule form, or anything but the free and endoglobular trophozoites.

It should be said that to the naked eye there is no morbid appearance presented by any of the viscera. The spleen seems never to be enlarged, and, as far as can be told, the liver does not appear abnormal. Neither do the uninvaded hepatic cells present any pathological condition beyond a slight degree of cloudy swelling. The vessels and capillaries are usually full of blood.

Further, it may be stated that numerous free forms (trophozoites or merozoites) (Plate XI., Fig. *e*) are, as a rule, present in smears made from the liver, kidney and bone-marrow, and to a less extent in those from the spleen. Once in the bone-marrow I noticed parasites which had been taken up by the large mononuclear leucocytes. (Plate XI., Fig. *e*). Several gerbils have been inoculated from infected jerboas but always with negative results.

Differences from *H. gerbilli* (Christophers)

Professor Laveran writes me to say that he has now found the same parasite in jerboas (*J. orientalis*) from Tunis, so that, no doubt, much information will soon be forthcoming regarding this interesting parasite of mammals. Thanks to the kindness of Captain Patton, I.M.S., I have received one of Lieut. Christophers' smear preparations of the infected blood of the *Gerbillus indicus*. His parasite closely resembles that found in jerboas, but presents some points of difference. Thus it exhibits chromatin dots much more frequently and in more abundance. Further, forms showing a tapering end turned up so that the parasite approaches a V shape, are much more in evidence.

A Leucocytozöon of Mammals

A new leucocytozöon *L. muris*

In May, 1905, while examining the blood of a Norway rat (*Mus decumanus*), to see if the animal was the host of T. Lewisi or harboured the hæmogregarine I had found in jerboas, I came across a parasite very similar in appearance to the latter, but situated in the extra-nuclear portion of the mononuclear leucocytes. The parasite, which is ovoid in shape, has a well-marked nucleus separating two lightly staining portions. Its ends are rounded and its dimensions in stained specimens between 9 μ and 10·5 μ in length by 4·5 μ in breadth.

Although it is usually found in the light staining portion of the leucocyte I have come across it lying between the lobes of a divided nucleus. (Plate XI., Fig. *f*). Thus it appears to be of the nature of a karyolysus such as has been described in lizards. I have examined the bloods of twelve Norway rats, six of them being young animals, and I have found the parasite in two instances. In the case of the first rat it was found in the heart's blood and in the spleen. In the latter, free forms were present in addition to those lying in the leucocytes. The liver was congested, but neither in smears nor in sections were any parasites visible. Section preparations revealed a condition of early chronic venous congestion resulting in pressure atrophy of hepatic cells which stained badly and had lost their nuclei.

No parasites were present in smears made from the kidney or bone-marrow. The

animal died suddenly on the morning of the day following that on which it had been brought to the laboratories. It was lively and apparently uninjured the previous evening. Rat number two also died the morning after capture. Parasites free and in the leucocytes were found in smears made from the spleen, liver and kidney, but they were not at all numerous.

Smears made from congested areas in the stomach and small intestine, and from the bone-marrow showed nothing abnormal. No free motile trophozoite and no cytocyst or other stage has been found.

I have examined the bloods of many Egyptian rats (*Mus Alexandrinus*) with negative results. The species examined has numerous yellowish-golden hairs on the snout.

This parasite is interesting in the light of the leucocytozöon found by Bentley in dogs in India, and described by him and by James. It is closely allied to, if not identical with, the

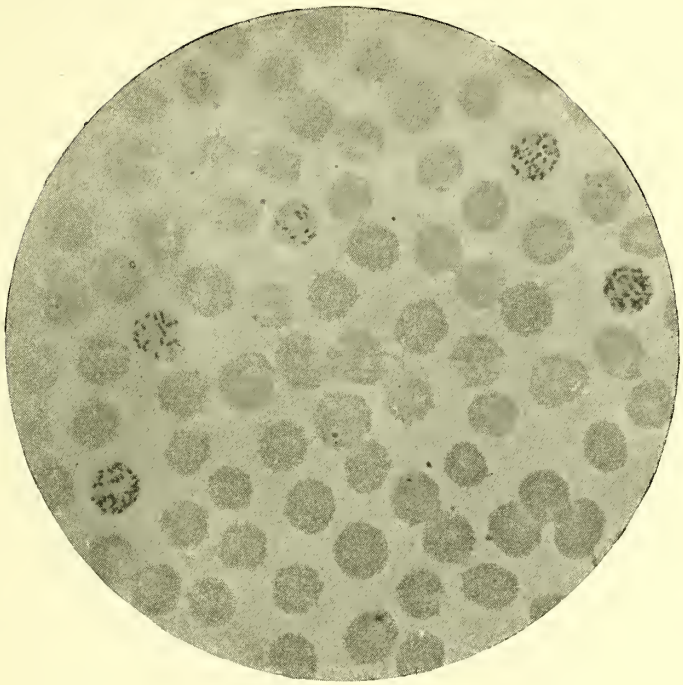


Fig. 61.—Changes in erythrocytes of jerboa (× 1000 diam.)

parasite recently discovered by Patton in one of the Indian palm squirrels. Captain Patton has very kindly sent me a blood film containing his parasites, which very closely resemble those in the Norway rat at Khartoum. I notice they are frequently found splitting the karyosomes of the mononucleated cells. He has also sent me specimens of a similar parasite found in the domestic cat at Madras.

I propose to give the name of *Leucocytozöon muris* to the rat parasite, which evidently requires further study on the lines which have been followed in connection with the hæmogregarine of jerboas.

Changes in the Erythrocytes of the Jerboa

As stated elsewhere, granular basophilia is common in gerbils. In the blood of several jerboas a somewhat similar condition has been observed, and it is shown in Plate XI., Fig. *a*, and in Figs. 61 and 62. In the last figure, besides the intracorpuscular dots and rods,

free forms can be seen. At first sight the appearances presented seemed to me rather different from the granular basophilia found in gerbils, and a slide was sent to Professor Laveran. He gave it as his opinion that the condition was merely one of basic degeneration. Later the free forms were seen, and Dr. Graham Smith's* paper on a new blood parasite of the mole appeared. The photomicrographs of infected mole's blood presented an appearance precisely similar to what had been seen in the blood of jerboas. I drew Professor Laveran's attention to this, and he replied that he regarded Dr. Graham Smith's preparations, some of which he had seen, as merely containing a pseudo-hæmamœba, and that he saw no reason to alter his opinion regarding the blood condition in the jerboa. I also wrote to Professor Nuttall on the subject, but have not heard from him. It is difficult to account for the free dots and rods which have evidently escaped from infected erythrocytes, but at present one need not enter more fully into the matter, which, however, is of some interest, and seems worthy of mention.

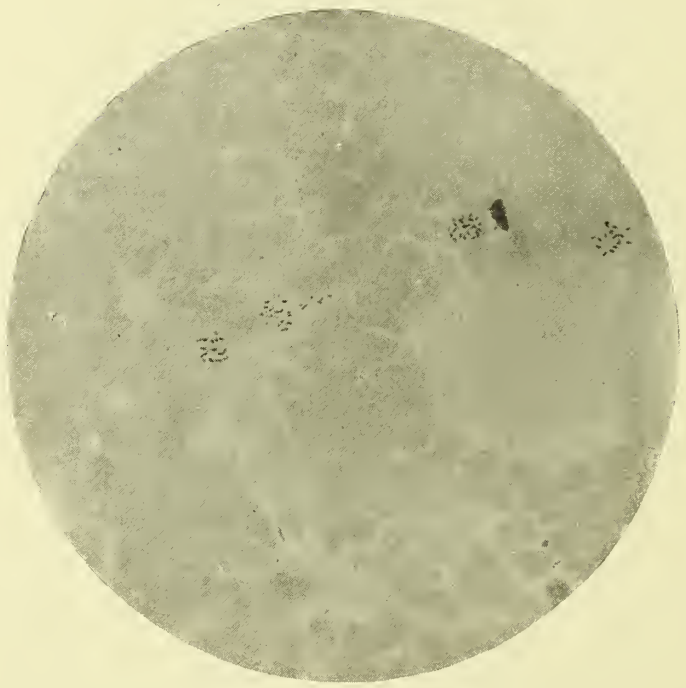
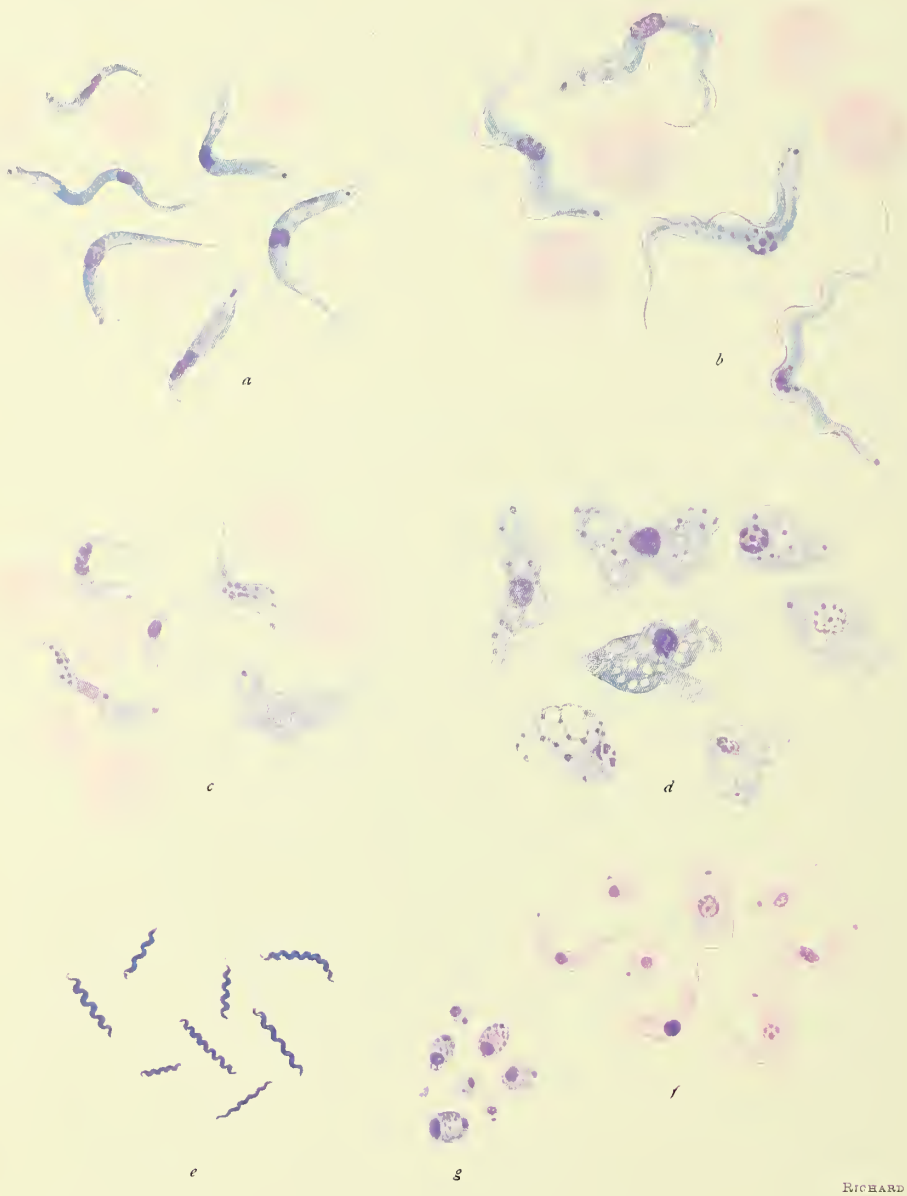


FIG. 62.—CHANGES IN ERYTHROCYTES OF JERBOA (× 833 diam.)

* Journ. Hygiene, Oct. 1905.

PLATE XIV



RICHARD MUIR

TRYPANOSOMIASIS

(*a*) T. nanum, the cattle trypanosome of the Sudan.
(*b*) T. gambiense, from blood of monkey inoculated from the Uganda boy, Wariga.
(*c*) Irregular forms of the trypanosome of mules as seen in the blood of the gerbil and monkey. Note the chromatin granules, the small "tadpole" form, and the "shadow" form.
(*d*) Degenerated and vacuolated forms of mule trypanosome as found in the peripheral blood of monkeys treated by chrysoidine and the blood serum of water-bucks.
(*e*) Spirilla found in the gastric and intestinal lesions. From gastric ulcer in a dog.
(*f*) "Ruddy" forms of trypanosome found in the gastric lesion in an inoculated jerboa.
(*g*) Torula (yeast-cells), apt to be mistaken for Leishman-Donovan bodies in stained preparations. From stomach of an inoculated jerboa.

Leishman Stain *All* × 1000 *diam.*

Trypanosomiasis in the Anglo-Egyptian Sudan*

I.—Prevalence and Distribution
II.—The Disease in Cattle

In the *British Medical Journal* of 26th November, 1904, I published a preliminary note on the above subject. This article referred to the fact that I had found trypanosomes in the blood of a donkey from the Bahr-El-Ghazal, that Head † had discovered similar parasites in mules from the same region, and that in smears from the blood of Shilluk cattle which he had submitted to me for examination I had found these flagellates. Since that paper appeared, a considerable amount of information has been obtained, and a good deal of research work has been carried out in the laboratories, upon what is a very important subject in a country like the Sudan. The following are the chief points to which I wish to direct attention:—

1. The prevalence and distribution of trypanosomiasis in the Sudan.

2. The presence in cattle of a small trypanosome which Laveran‡ has declared to be a new species, and which he has named *T. nanum*.

3. The question as to whether equines, or at least mules, are liable to a double infection by two different species of trypanosomes, or are the hosts of a *T. dimorphum* or *dimorphon* resembling that which affects horses in Senegambia.§

4. The great frequency of hæmorrhagic ulcerative lesions of the stomach in trypanosomiasis and their significance, also the comparative frequency of intestinal ulceration.

5. The occasional presence of spirilla in these gastric lesions, both in the blood clot adherent to the ulcers and in the ulcerated surfaces.

6. The action of chrysoidine as a therapeutic agent in trypanosomiasis.

7. The therapeutic action in trypanosomiasis of the blood serum of wild animals (big game) whose habitat is in trypanosome-infected areas, a line of research suggested by Dr. Sheffield Neave (*vide infra*).

Prevalence and distribution

I. As Regards Prevalence and Distribution.—There can be little doubt that in the Southern Sudan, that is to say, in the region south of the tenth parallel of latitude, trypanosomiasis exists to a very considerable extent. An illness known to be due to the bites of tsetse flies, and affecting donkeys, horses, mules, and possibly camels, has been recognised in the Bahr-El-Ghazal province since that distant region was visited after the reconquering of the Sudan. Expeditions have experienced considerable losses in transport animals from this cause. Again, and more recently, sick and emaciated animals have been coming from the Upper Sobat district, and especially from the neighbourhood of Itang, a station on the Baro River in Abyssinian territory. This is explained by the discovery of a tsetse fly-belt between Gore and Gambela Fig. 11 (p. 28) and the disease will do much to hamper the trade with Abyssinia which is largely conducted by means of pack mules.

Association with the tsetse fly

Old records also speak of animals dying from fly bite on the upper reaches of the Blue Nile, but accounts are so vague, both as regards the nature of the illness and that of the fly

* Portions of this paper have already appeared in the "Journal of Tropical Medicine," the "Journal of Pathology and Bacteriology," and the "Edinburgh Medical Journal." The Editors of these journals have kindly permitted their reproduction here.

† Journ. Comp. Path. and Therap. Edinburgh and London, 1904, Sept. 30th.

‡ Comp. rend. Soc. de Biol. Paris, 1905, Feb. 24th.

§ Dutton and Todd, First Report of the Trypanosomiasis Expedition to Senegambia, 1902; Liverpool, 1903.

said to cause it, that no definite conclusion can be reached regarding the prevalence of trypanosomiasis in that region. No cases have been sent me from the Blue Nile provinces, and I have not received samples of tsetse flies from these parts, nor seen them between Roseires and Wad Medani, where the river is more or less bordered by bush and forest. In the Northern Sudan, the region of sandy wastes, as pointed out in the preliminary note, trypanosomiasis has not been found to exist, but no great number of examinations have been made, and investigations upon frogs, lizards, and a large number of birds have yet to be conducted. Captain Head, of the Veterinary Service, however, informs me that he has examined the blood of a large number of cattle and camels, both in the Berber district and on the borders of Abyssinia, and has not encountered a single case of trypanosomiasis. In some of the districts in which he worked, *Pangonia* are prevalent. Dr. Sheffield Neave, travelling pathologist to the laboratories, worked down Nile from Gondokoro, and the reader is referred to his report for accounts of the trypanosomes which he has discovered and described. His finds in birds are specially interesting in the light of Novy's and McNeal's recent researches.*

Trypanosomes in birds and fish

For the purpose of gathering information and material regarding the trypanosomiasis of Shilluk cattle I accompanied Colonel Griffith, the principal veterinary officer, to Taufikia, near the mouth of the Sobat River, and 526 miles south of Khartoum. The journey was undertaken in January, 1905, and at Melut, fifty miles north of Kodok (late Fashoda), a herd of Shilluk cattle was inspected. Three sick animals were picked out and examined. In the blood of one of these I found a trypanosome identical with the parasite found in Shilluk cattle at Khartoum which had come from the Kodok region.† Nothing was found in the blood of the other two animals, but it is probable they were suffering from the disease, as they presented the characteristic symptoms, *i.e.*, extreme anæmia of the mucous membranes, weakness, emaciation, and some running from the nose. At Melut we received vague information as to the presence of a fly belt a considerable distance inland, and were told that the cattle became infected after the rainy season, *i.e.*, in August. On these cattle, as in those at Khartoum, large numbers of the tick called *Amblyomma variegatum* were found, as well as flies of the genus *Hippobosca*. It may be said at once that examination of these insects has always proved negative, but, as will be shown, the trypanosomes are never very numerous in the blood of cattle.

Investigations on the White Nile

A herd which had just been imported from the north showed no signs of disease.

At Kodok a small herd was seen, and one sick cow, which eight months previously had come from Melut, was examined. It was distinctly thin and anæmic, but no parasites were found in its blood.

At Taufikia, six separate herds of cattle were inspected, the bloods of 12 sick beasts were examined, and trypanosomes were found in one animal only—a cow from Abyssinia, which had recently aborted, and was in a dying condition.

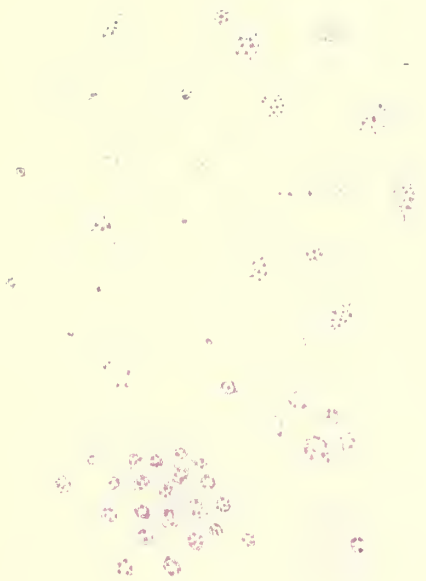
This trypanosome proved to be *T. nanum*. Three sick mules, coming also from near Itang, were found to harbour trypanosomes. These were not the same species of parasite as those found in cattle, but appear to be identical with those discovered by Head in mules from the Bahr-El-Ghazal. A dog was inoculated from one of these mules and brought to Khartoum, where it developed trypanosomiasis. It was from this strain, carried on by

T. nanum, the cattle trypanosome

* Jour. Infec. Dis., Chicago, 1905, March.

† The recent discovery of *G. morsitans* in Southern Kordofan probably explains the prevalence of tsetse disease in this district.

PLATE XV



RICHARD MUIR

ORDINARY AND ALTERED FORMS OF BLOOD PLATES FROM PERIPHERAL BLOOD OF CATTLE

Some of these, in stained preparations, are apt to be mistaken for parasites as they possess chromatin dots and may simulate flagellated bodies.

Leishman Stain × 1000 *diam.*

successive passages through animals, that I have been able to study the parasites of the disease in mules. The cow from Melut was also brought to Khartoum, and will be again mentioned in due course. At Taufikia, a monkey (*Cercopithecus sabæus*), a bat, and a black and white crow were examined, with negative results.

Out of three sparrow-like birds examined, two showed halteridia in the blood.

It is difficult to base any conclusions on such limited observations. The trypanosomiasis of cattle is a chronic disease to all appearance, and it will be some time before its prevalence is correctly gauged. In equines the malady appears to be common in the Bahr-El-Ghazal, where *G. morsitans* is found, and probably exists to a considerable extent on the Upper Sobat, where, as stated, it is quite possible that *G. longipennis* exists. On the mules at Taufikia large numbers of a species of *Stomoxys* were found, biting fiercely, specially in the evenings. No opportunity of properly examining these flies was afforded. In one, which was dissected, no trypanosomes were found, but several hours had elapsed before its stomach contents were examined. One may here refer to human trypanosomiasis which so far has not been encountered within the confines of the Sudan,* though, as previously noticed, Dr. Neave† found Leishman-Donovan bodies in the spleen of a boy coming from Meshra, in the Bahr-El-Ghazal. This is of especial interest in the light of the subsequent discovery of *G. palpalis* in the Bahr-El-Ghazal province and the Lado Enclave, albeit Meshra is hundreds of miles away from these infected regions, and the relationship of Leishman-Donovan bodies to trypanosomes has not yet been definitely settled. At Taufikia I found that the Sudanese battalion was being recruited to some extent from Uganda, and discovered that twelve men had come from Kampala, close to Entebbe, a centre of the disease. Some of these men exhibited enlarged cervical glands. They were tested by blood examinations, gland puncture and, in one specially suspicious case, inoculation into a monkey (*Cercopithecus*), but with wholly negative results. Later they were sent for observation to Khartoum, and were re-examined, but no trypanosomes were found. The presence of these men at Taufikia, however, served to draw attention to what was undoubtedly a source of danger. Recruiting from Uganda was at once abolished by order of the then Principal Medical Officer, Colonel Penton.

Captain Greig‡ has shown that the country immediately south of Gondokoro is not of the kind likely to harbour *G palpalis*, but later information has been obtained by Dr. Neave and is included in his report, together with his own observations on the Upper White Nile and between Shambe, Runbek, Tong and Meshra-El-Rek.

The disease in cattle

II. *The Disease in Cattle.*—Cattle trypansomiasis has been studied at Khartoum, Melut, and Taufikia. The disease appears to be of a chronic nature, the principal symptoms being extreme anæmia, especially visible in the blanched, glistening conjunctival surface; weakness, emaciation, running from the nose, and, occasionally, dribbling of urine. The last condition is probably dependent on muscular weakness. Fig. 63 gives a good idea of an animal suffering from the disease. Notice the dull, listless, half-closed, and sleepy eye, the prominent ribs and hip bones, and, what is rather constant, the atrophic line in the shoulder hump. In the later stages the head is held low, and towards the end there is complete collapse, the animal lying down and refusing to rise, the skin cold, the coat roughened, urine and fæces passed involuntarily, and the respirations noisy and rapid. At this stage the animal

Symptoms

* It is important to note that Todd mentions the occurrence of a case of Sleeping Sickness in the Lado Enclave. Thompson Yates and Johnston Laboratories Report Vol. VI., New Series, Part II., Liverpool, 1906.

† Brit. Med. Jour., London, Vol. I., 1904, May 28th, p. 1252.

‡ Lancet, London, Vol. I., 1905, Feb. 25th, p. 534.

may take food, and, indeed, failure of appetite does not at any time seem to be a symptom. Careful examination failed to detect enlarged glands towards the root of the neck, but one is apt to be deceived by feeling the subcutaneous, gelatinous exudation which is found to

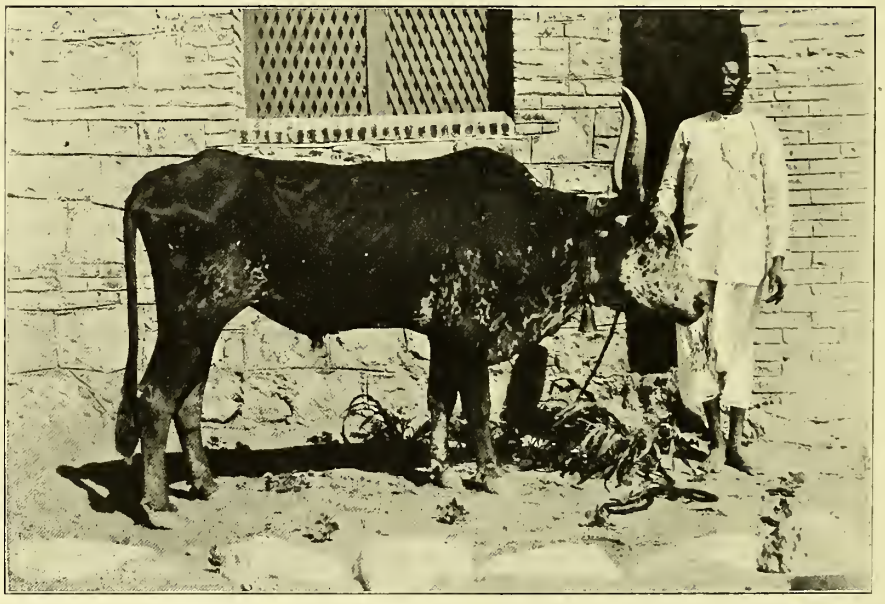


Fig. 63.—Shillux Ox suffering from Cattle Trypanosomiasis

exist post-mortem. The first ox from which specimens were obtained died some fifteen miles from Khartoum. Smears of the peripheral blood, liver, and spleen were submitted to me by Captain Head. In all of these I found the small trypanosome, since named *T. nanum* by

Fig. 64.—Stomach of Ox, showing ulcerated patches of mucous membrane

Professor Laveran. Captain Head also brought in some of the cerebro-spinal fluid, which was centrifuged, and in the sediment streptococci, possibly due to contamination, and altered and amœboid forms of the parasite, were found. The latter resembled those described by

Plimmer and Bradford* in bone-marrow in cases of nagana, and by Castellani† as occurring in the cerebro-spinal fluid in sleeping sickness. They were few in number and stained feebly. A somewhat pear-shaped, flagellated form was the most striking.

The second ox also died at a distance. In smears made from its blood trypanosomes were fairly numerous. The stomach, which had been placed in spirit, was the only organ brought to the laboratories. Attached to it was a small piece of omentum. On opening the stomach a very curious condition of pigmented ulceration was disclosed, affecting the mucous membrane (Fig. 64). Scattered about were dark areas with thickened edges raised above the surrounding mucous membrane. The surfaces of these areas were flat and slightly depressed, and consisted of what was afterwards found to be altered blood clot. No smears were made from these areas, but sections were cut and examined. Beyond a severe bacillary invasion and the appearance of considerable erosion and destruction of the mucous membrane, nothing was found.

Gastric ulceration

The following are my notes on the condition :—

"*Examination of Abomasum or Fourth Stomach—Cardiac end.*—Nothing noticeable externally. In a small piece of attached omentum there are two enlarged glands about the size of peas, rounded, elastic to the touch, purple in colour externally, and deep purple on section. The mucous membrane is of a uniform dark slate colour, no ecchymoses are present, but there are some dark patches, possibly due to post-mortem changes. Studded over the surface of the mucous membrane are spots of intensely black pigment (Fig. 64). Each of these, in most instances, seems to surround a tiny punched-out-hole, and the pigmentation is most marked in the central depression. A few black granules can, as a rule, be squeezed out from the central pits. These granules were found to consist of altered blood. Where the patches are more advanced, they present the appearance of ulcerations. Most of these are more or less circular and depressed, but some are in the form of ulcerated streaks, and all are intensely black. In addition there are a few patches of superficial pigmentation in which there is no ulcerative process.

Central portion.—The condition is very similar, but the patches are larger, some of the ulcerated "streaks" being $\frac{3}{4}$ inch in length. In one or two places the ulcerations appear to have healed, leaving depressed and whitish scars surrounded by areas of slight pigmentation.

Pyloric end.—Nothing noted externally. The mucous membrane shows a general pigmentation of the surface in the form of little circular shallow pits with pigmented walls, the pigmentation being very slight. In addition, pigmented ulcers, similar to those previously described, are present in considerable numbers, and in some instances a regular plug of the black material fills up the ulcer and rises above the surface of the mucous membrane. There are also present the superficial pigmentations already mentioned, some of which are associated with slight erosion. Where the ulcers are marked, their edges are thickened. The ulcerative process and the pigmentation are confined to the mucous layer. In no instance does perforation seem to have occurred. Size of largest ulcer, $\frac{3}{4}$ inch by $\frac{1}{4}$ inch."

At the time I did not think that these ulcerations, which rather recalled the lesions produced by the swallowing of a corrosive poison, were in any way connected with the trypanosomiasis. Since then I have had reason to alter that opinion, as will be seen when we consider the experimental work with the trypanosomes of mules. Captain Greig, whom I

* Brit. Med. Journ., London, Vol. I., 1903, June 20th.

† Journ. Tropical Medicine, Vol. V., 1903, p. 167.

met on his way to England from Uganda, informed me that he had recently found a similar condition of ulceration in the stomachs of natives dead of sleeping sickness. He has described and figured this condition in his report to the Royal Society.*

The third ox is that shown on page 116, Fig. 63. The blood was taken at Khartoum on 30th October, and as many as two trypanosomes were found in some fields. The animal was kept and well fed. On 4th November fresh and stained blood films were examined, but no parasites could be demonstrated. Thereafter, though the blood was centrifuged and examined, and though the animal was subjected to four days' partial starvation, trypanosomes were not again found. Eventually, as the owner wished to slaughter the ox, it was exchanged for ox No. 4, which was examined on 23rd November, when a considerable number of trypanosomes were found, as many as six per cover-glass preparation being present. This ox continued to show the parasites in its blood, and gradually became thinner and weaker.

On 3rd December it was found to be very weak with marked anæmia and dribbling urine. The urine and fæces were examined for blood, but none was present. The fæces were slightly tarry in consistence, and this and their colour suggested the examination.

On 4th December the ox was found to be in extremis. Trypanosomes were slightly more numerous in the blood, and as it was feared the animal might die during the night, it was slaughtered, and an autopsy performed immediately.

Post-mortem findings

The principal points noted were :—

(*a*) The extensive subcutaneous, gelatinous, and pale yellow exudation. Nearly every part of the subcutaneous connective tissue was in an œdematous, watery condition, which was most marked where the skin was loose, *i.e.*, in the dewlap, behind the shoulders, and in front of the haunch.

(*b*) The presence of enlarged purple hæmorrhagic glands about the root of the neck.

(*c*) The great and general enlargement of the mesenteric glands, which were also, though to a less extent, hæmorrhagic in nature.

(*d*) The presence of a certain amount of chronic meningitis affecting the pia arachnoid, the pia being somewhat adherent to the surface of the convolutions. There was little thickening of the membranes, and no appearance of encephalitis. Indeed, the brain appeared markedly anæmic. The stomach, which was distended with food, presented no ulcerative condition, but contained "bots" of a different kind to any I have seen in the Sudan. The intestinal tract was normal. There was nothing special to note with regard to the spleen and liver, which were neither congested nor enlarged. The heart's blood showed trypanosomes. Fluid from the lateral ventricles of the brain and from the cerebro-spinal fluid showed nothing in the way of trypanosome infection. Bile taken with aseptic precautions from the gall bladder contained a short stout bacillus in considerable numbers, but no flagellated parasites.

The cow at Melut was picked out by the natives as being ill. The blood was collected in tubes containing citrate of soda solution. Such blood showed trypanosomes, though these were only found after some searching.

The Abyssinian cow which aborted at Taufikia, and was in a dying condition, also had trypanosomes in its blood, but they were not at all numerous. Time did not admit of a post-mortem examination in this case.

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* Reports of the Sleeping Sickness Commission of the Royal Soc., London, No. VI., p. 266, Plate VII.

Morphology of T. nanum

The trypanosome concerned is a small one. (Plate XIV., Fig. *a*.) It is not very active in fresh films, and I have never seen one traverse the whole field of the microscope. The motion is undulating, combined with a vigorous lashing to and fro of the anterior part of the body, which tapers to a very tiny flagellum. Rippling, and what may be termed spreading, movements have also been observed. The parasite advances usually with the narrow end in front, but this motion is often reversed, and I have seen one move a considerable distance, pushing aside the erythrocytes with its blunt posterior end. A fact which is very noticeable is that the trypanosome tends to adhere to the red blood corpuscles. Even in a thin field this is seen, the parasite seeming to take a delight in butting and boring at the erythrocytes. Frequently it gets beneath them and is lost to view, the agitation it produces being the only clue to its presence. Having studied this trypanosome, both in the living and stained condition, and having conducted a few inoculation experiments on laboratory animals (*vide infra*), I became convinced that this was either a new and undescribed trypanosome, or was identical with the parasite of cattle found by Bruce, Nabarro, and Greig on the shores of the Victoria Nyanza in Uganda. Stained specimens were sent to the Liverpool School of Tropical Medicine, but I learn that unfortunately the stain had faded and could not be repeated with success. In the meantime I had sent unstained films to Professor Laveran,* to whom I am much indebted for his kindly interest, and who, in the Proceedings of the Biological Society of Paris of 24th February, describes the stained trypanosome, which he regards, provided further experiments prove it to be peculiar to cattle, as a new species, and which, on account of its small size, he has named *T. nanum*, *i.e.*, the dwarf trypanosome.

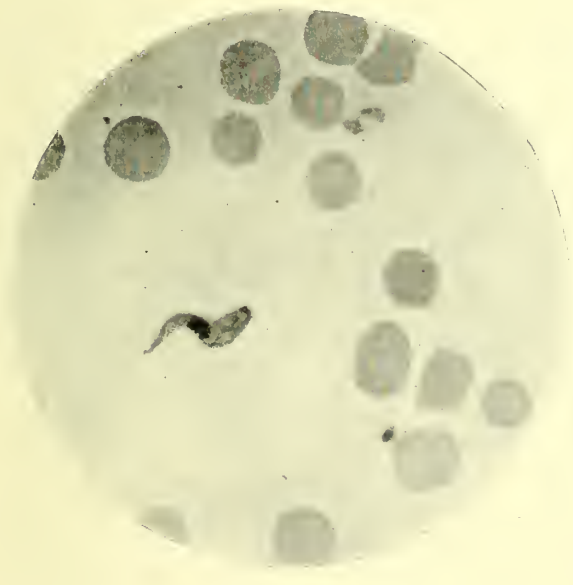


Fig. 65.—T. Nanum. × 1750 diam.

His interesting description of these parasites is as follows:—

"The trypanosomes measure 10 to 14 μ in length, by $\frac{1}{2}$ to 2 μ in breadth. Their structure is that of the flagellates of the genus trypanosoma, although, contrary to the rule, the protoplasm is prolonged on the anterior part in such a way that there is no free part of the flagellum, or the free part of the flagellum is extremely short. The undulating membrane is very straight, and in consequence but little apparent. The posterior extremity is conical, not drawn out, and in other respects varies somewhat. The oval nucleus is situated near the centre of the body of the parasite. The rounded centrosome, rather large, occupies a position close to the posterior extremity. The protoplasm is homogeneous without granules.

"Some forms a little longer than the others show two centrosomes and a flagellum, divided to a greater or lesser extent, proceeding from the centrosomic insertion."

* Compt. rend. Soc. Biol., Paris, 1905, Feb. 24th.

He proceeds to point out how different in morphology is this trypanosome from *T. Brucei* and *T. Evansi*. He compares it with *T. Theileri*, the giant trypanosome of South African cattle, and concludes by remarking that while very distinct from *T. Theileri*, *T. nanum* approaches it in being peculiar to cattle, so far as is at present known.

I have little to add to the above description. (*vide* Plate XIV., Fig. *a*.)

The photo-micrograph (Fig. 65), for which I am indebted to Dr. Beam, chemist to the Laboratories, gives a very fair idea of one of the shortest forms of *T. nanum*. It shows it to be a short trypanosome with hardly any free flagellum visible, but is not quite typical in that the posterior moiety is rather broader than is usually seen.

I append measurements I have made of a form whose total length was 14 μ.

From posterior end of body to centre of centrosome	1·2 μ
From centre of centrosome to nucleus	4·2 μ
Nucleus	1·6 μ
From nucleus to beginning of flagellum	5·6 μ
Free flagellum	1·4 μ
Breadth behind nucleus	2 μ

I agree that the protoplasm is homogeneous, though it sometimes stains irregularly, as evidenced in Fig. 65, while in forms kept *in vitro* granules appear, for the most part anterior to the nucleus. In such forms the vacuole in the neighbourhood of the centrosome may be found large and very evident. Sometimes a portion of the free edge of the undulating membrane is clearly visible, bunched as it were upon the back of the trypanosome and looking like a loop. As a rule, however, the undulating membrane can scarcely be seen save in the living parasite. I have worked with specimens stained by the Leishman-Romanowsky method, which answers admirably if the stain be strong and staining prolonged. After fixing with the alcoholic stain in the usual way I am in the habit of adding an equal quantity of distilled water and allowing the stain to act for from twenty minutes to half-an-hour or even longer.

I have carried out a few experiments *in vitro* which may be mentioned here, though the study of the trypanosome is yet far from complete, owing to lack of material and press of other work. Hence cultivation experiments have not been attempted.

In citrated blood kept at a temperature of 22° to 23° C., no change in the trypanosomes was visible after twenty-four hours. They remained lively and stained well. After seventy-two hours at a temperature of 25° C., changes were observed to have occurred, the posterior ends of the parasites having become swollen, while the organisms were sluggish and evidently degenerating.

Trypanosomes disappeared in 24 hours from sterile citrated blood which had been exposed to a temperature of 16° C.

The trypanosomes from the Melut cow remained alive in non-sterile citrated blood at a temperature of about 35° C. for twenty-four hours. They underwent longitudinal division, forms with two centrosomes and two nuclei being seen. In these the undulating membrane was more apparent than usual.

Inoculation experiments

Inoculation Experiments. From Ox No. 1.—0·5 c.c. citrated blood, *i.e.* about 0·25 c.c. blood, was inoculated subcutaneously into a monkey (*Cercopithecus sabæus*) on 30th October, 1904.

On the same date a rabbit received 1 c.c. of citrated blood. These animals never showed any symptoms of the disease, and though their bloods were repeatedly centrifuged

in the hæmatoerit tubes, and earefully examined both in the fresh and stained condition, no trypanosomes were found.

From Ox No. 4. On 23rd November a rabbit reeeived 2 e.c. of blood containing a eonsiderable number of trypanosomes, six to the microscopic field (employing Leitz, obj. 6, oe. 4, without oeular diaphragm), and a monkey (*Cercopithecus*) received 1 e.c. The result in the ease of these animals was also negative, though they remained under observation for two months.

On 4th Deeember a brown pariah dog reeeived 2·5 e.c. of fresh blood subeutaneously at a time when trypanosomes were fairly numerous.

A black pariah dog reeeived as food large pieees of the liver and spleen and several of the enlarged glands, all soft food be it noted.

These experiments also proved absolutely negative.

On 29th Deeember the last-mentioned rabbit happened to be killed accidentally. A post-mortem was performed immediately, but no trypanosomes were found in the blood or in any of the organs. It would appear, then, that dogs, rabbits, and monkeys (*Cercopithecus*) are not liable to infeetion with *T. nanum*, though it must be eonfessed that the number of experiments was too small. As it was desired to institute further experiments, the cow from Melut was brought to Khartoum, arriving there on 4th Mareh, 1905, along with her ealf. The blood of both animals was examined, but no trypanosomes were present

The eow, and there was no doubt as to her identity, was in very poor condition and presented all the symptoms of the disease, but repeated centrifuging of considerable quantities of blood failed to reveal the parasites. On 7th March, 1905, 4 e.e. of the cow's fresh blood was inoeulated subeutaneously into her calf, but though numerous examinations have been made of the blood of the latter, *T. nanum* has not onee been found. Nor has the eow again exhibited trypanosomes up to the time of writing (December, 1905). She was well fed and steadily improved in health and appearanee. In this eonneetion one must note that the Uganda experiments indieated that there is no transmission of immunity from a trypanosome infeeted animal to her offspring and that an apparently recovered animal may months later, as a result of lowered vitality, again exhibit infeetion (*vide* Lancet, May 14th, 1904).

A sample of her milk was analysed by Dr. Beam and yielded the following figures :—

Total solids	21·5 per eent.	
Fat	11·2 „ „	(a very high figure).
Solids not fat	10·3 „ „	

I had neither the time nor the means at my disposal to eonduet an extensive series of eattle inoculations, nor was I able to seeure other eattle suffering from trypanosomiasis.

Taken in eonjunetion with what was found in Ox 3 it would, however, appear that *T. nanum* is in the habit of disappearing for long periods from the peripheral blood, and I am strongly inclined to think that spontaneous cure may oeeur. It is possible that, under favourable eonditions, sueh as removal from an endemic area and plenty of good food ensured, a trypanosomicide is produeed in the blood whieh proves fatal to the parasites. Supposing for a moment that this be the case, it may prove possible to utilise the sera of reeovered eattle as a therapeutie agent. I hope yet to be able to exploit this field of research whieh, though already explored to some extent in the case of other trypanosomes, seems well worth investigating in the ease of a new and undoubtedly somewhat benign form like *T. nanum*. A proper animal house, however, would be required, and more assistance than is at present available, while the undertaking would be somewhat eostly, as I have not yet

Possible spontaneous cure

found a laboratory animal liable to infection with this trypanosome of cattle. One rather interesting experiment has, however, been tried. On November 17th, 1905, the calf whose blood was examined and found, as before, free of parasites was inoculated with 1·5 c.c. of blood from a monkey. This blood was swarming with the long and short forms of the trypanosome of mules (probably *T. dimorphum*), to be presently described, and the experiment was carried out to see if the short form in mules was *T. nanum* which it resembles. It would have been better to try the experiment from this point of view on a clean animal, but none was available.

On November 23rd, for the first and, as it turned out, the last time, a few long forms were found in blood taken from the ear. Since then the calf has remained fat and well, and its blood is free from parasites.

III.—The Disease in Mules

IV.—Prophylaxis and Treatment, etc.

The disease in mules

III. For the study of trypanosomiasis in mules there have been available the stained slides of blood prepared by Captain Head from mules which were brought from the Bahr-El-Ghazal. The main source of material was, however, found in the three mules suffering from the disease at Taufikia. As stated, a dog was inoculated from one of these animals and brought to Khartoum, where it developed the disease. The symptoms and post-mortem appearances in mules have been very carefully described by Captain Head.* The accompanying photographs, Figs. 66 and 67, kindly given me by Colonel Griffith, P.V.O., demonstrate the aspect of an affected animal in an advanced state of the disease.

Fig. 66.—Mule Affected with Trypanosomiasis.

Symptoms

Note the hanging head, the dull and listless eye, the roughened, staring coat, the prominent ribs, the general aspect of hopeless resignation, and the hind leg projected from the body, a sign of weakness or of giddiness.

* *Journ. Comp. Path. and Therap.*, Edinburgh and Glasgow, 1904, Vol. XVII., p. 200.

The blood of the mules seen at Taufikia literally swarmed with trypanosomes, and was thin, greasy, and difficult to spread on the slide. One animal died but had decomposed before we got word of its decease. The death of a second enabled a post-mortem to be performed. The most marked change was in the meninges which were much thickened, the dura being very adherent to the skull. The brain was congested and the cerebral vessels gorged with blood.

Post-mortem appearances

Otherwise but little was found, the spleen not showing any increase in size or marked congestion. The liver was fatty. Unfortunately the stomach was not opened, a regrettable

Fig. 67.—Mule Affected with Trypanosomiasis.

oversight on my part. It looked healthy viewed externally. There was no gelatinous subcutaneous exudation nor was the connective tissue œdematous.

From the third mule the dog was inoculated, about 4 c.c. being given subcutaneously on January 16th, 1905. On January 22nd, 1905, trypanosomes were for the first time found in this dog's blood. Slides of the mule's blood were sent to Professor Laveran, who describes the forms found in the same article as that in which he deals with *T. nanum*, the trypanosome of cattle.

Morphology of the mule trypanosomes

After remarking that the parasites were very numerous, he proceeds to distinguish two types.

"A. Small forms measuring 12 to 14 μ in length by 1·5 μ to 2·5 μ in breadth. These trypanosomes recall very much the appearance of the small forms of *T. dimorphon*. The protoplasm is prolonged as far as the extremity of the flagellum, which in consequence does not exhibit a free part. The undulating membrane is more developed than in *T. nanum* and causes the parasite to present an even more "stumpy" aspect. The nucleus is situated sometimes at the centre, sometimes at the junction of the posterior with the middle third. The protoplasm contains chromatin granules and these are sometimes very numerous. Forms in process of division are encountered with two centrosomes and one nucleus, two centrosomes and two nuclei, etc.

"B. Large forms measuring 21 to 30 μ in length by 2 μ in breadth. Those forms, in which the flagellum exhibits a very long free portion, bear a great resemblance to *T. Evansi*. The posterior extremity is usually elongated, the protoplasm is homogenous and with but few granules. Forms undergoing division by separation into two elements are found.

"It is to be noted that intermediate forms between the small and the large trypanosomes are wanting."

From a study of numerous preparations both fresh and stained I am in a position to add a few additional notes to the above.

In fresh blood both forms of trypanosomes can be clearly made out. The long forms are much the more active, darting rapidly hither and thither, lashing vigorously with their flagella, and displacing the red blood corpuscles. They can advance with either the anterior or posterior end in front, though their longer excursions are made with the flagellum "going on before."

Occasionally one of these long active forms may be seen to traverse the field of the microscope, but this is not common. The body of the trypanosome frequently bends upon itself so that it presents the appearance of a tiny corkscrew for the fraction of a second, and then, stretching out, the parasite shoots across some space amongst the corpuscles, and plunges writhing and lashing amongst a group of startled erythrocytes.

In the fresh state the undulating membrane is not very well defined in these long forms. They do not present a granular aspect. The short forms on the other hand are, as a rule, distinctly granular and are much more sluggish in their movements. They tend to hang about the same spot and their excursions are limited, rather resembling those of *T. nanum*. They also can advance with either end in front, but their body movements are more of a rippling or undulating type. It often looks as though a series of shivers was running along the protoplasm.

Their undulating membranes are well marked, and the rounded posterior ends are very distinct. On staining with Leishman-Romanowsky, used strong and for a considerable time as in the case of *T. nanum*, the differences in structure between the two forms are well emphasized. Points to which Laveran in his short note does not refer, are the well-known "pike-head" form of the posterior end of a typical long trypanosome, and the fact that the centrosome of the long form is not as large as that of the small.

In some of the short forms the nucleus seems almost to touch the centrosome, while "bunching" of the undulating membrane is often well seen. I have noted curious forms, possibly distorted, with square-cut posterior ends, and more than once have seen a short form with no granules visible.

As a rule the granules are in the posterior moiety, *i.e.*, between the nucleus and the centrosome. In some instances the possession of these chromatin granules is almost the only point enabling one to distinguish this trypanosome from *T. nanum*. I have also noticed dividing forms, and it is not uncommon to find two short forms lying with their posterior ends in close contact—possibly a preliminary stage to conjugation, more likely the terminal stage of a division.

In the mule's blood I did not observe conjugating or agglutinating, or involution forms. I agree that the long forms measure from 21 to 30 μ, but some are as narrow as 1·4 μ at their thickest portion.

I append a very average set of measurements :—

From posterior end to centrosome	2·8 μ
From centrosome to nucleus	7 μ
Nucleus	2·8 μ
From nucleus to root of flagellum	4·2 μ
Flagellum	6 to 10 μ

There is much variation amongst these long forms, but as a general rule the flagella stain admirably, and complete measurements can easily be made. Here are the figures for one of the short forms of a total length of 14 μ, in which the nucleus was at the junction of the posterior and middle third :—

From posterior end to centrosome	1·4 μ
From centrosome to nucleus	1·4 μ
Nucleus	2·8 μ (large)
From nucleus to root of flagellum	7 μ
Flagellum	1·4 μ

I have found short forms to vary in length from 12 μ to 15·4 μ, and in breadth from 1·4 μ to 2·5 μ.

As Professor Laveran points out in *T. dimorphum*, the trypanosome of horses in Senegambia there also exist two forms, a long and a short. He asks if this and the mule trypanosomes are identical. He regards it as possible, but mentions the fact that, while the short forms of the mule trypanosome resemble the short forms of *T. dimorphum*, the long forms of the former differ a little from those of the latter, mainly as regards the flagella, which, as a rule, are short in *T. dimorphum*. He adds, however, that variations occur and that Dutton and Todd* have described free flagella in the large form of *T. dimorphum*. Not only are they described, but they are figured both in photo-micrographs and coloured plates, and I must say that my first impression was that I was dealing with *T. dimorphum* or something very like it. To my mind the long forms more resembled the long forms of *T. dimorphum* than they did *T. Evansi*, but then my comparisons were made from photographs and coloured drawings. Laveran goes on to advance another hypothesis, namely, that the mules may have been infected with two different species of trypanosome, and he cites the work of Cazalbou† who in the French Soudan found horses to be the victims of a double infection.

There seems no reason why this might not occur, and as regards the short forms one at once thinks of *T. nanum*, as the mules had come from the Itang district along with the herd of cattle, amongst which was the cow harbouring those flagellates. This cow aborted and died as already described.

In order to try and settle this vexed question and to enable one to test certain therapeutic measures animal inoculations have been conducted.

As mentioned, a Shilluk dog, whose blood was previously tested and found normal, was inoculated from one of the mules at Taufikia, receiving 4 c.c. of undiluted blood subcutaneously. It was brought at once to Khartoum, where a fly-proof animal house has been erected, and there it developed trypanosomiasis, the parasites appearing in the blood after an incubation period of about seven days.

From this dog, whose blood exhibited the same state of things as was found in the mule, various passages of the parasites have been made. Those performed up to the present time

* First Report of the Trypanosomiasis Expedition to Senegambia, 1902, Liverpool, 1903.

† Réc. de Méd. Vét., Paris, 1904, Oct. 15th.

are shown in the annexed table (p. 127), and it is proposed to deal with each experiment in turn and then to consider the result as a whole.

Inoculation experiments

In each instance, with one exception due to a mistake, the blood of the experimental animal was carefully examined prior to inoculation.

Exp. 1. Dog 1.—Young Shilluk dog, about eight months old.

January 16th, 1905. 4 c.c. fresh blood of mule injected subcutaneously.

January 22nd. Trypanosomes found in the peripheral blood.

February 8th, found dead.

This dog ran what proved to be a very typical course for the disease in dogs characterised by progressive anæmia, weakness and emaciation with, in the later stages, double corneal opacity. Towards the end the creature had become a veritable skeleton. The appetite did not fail till just before death and no nervous symptoms, except increasing drowsiness, were noted, nor was there any œdema or effusion.

At the autopsy, the most noticeable feature was a large effusion into the pericardium. Being ill at the time I did not see the post-mortem, but I understand that no gastric ulceration and no enlargement of glands was found.

I believe this may have been due to the fact that the dog, a young animal, died at a comparatively early stage in the disease. The blood was noted as being very thin and greasy.

The following is the temperature record from January 30th, taken per rectum, about noon of each day, 102·8° F., 103°, 102°, 104·6°, 101·6°, 103·2°, 98·8°, 98·4°, 101·2°. It will be noted there was a lowering of the body heat towards the end of life.

Exp. 2. Dog 2.—Inoculated subcutaneously from Dog 1 on January 23rd, about 2 c.c. citrated blood being given. Blood examined for the first time on February 4th, when trypanosomes found. For a few days prior to this the dog had shown signs of commencing emaciation. At a slightly later period it exhibited to a slight extent the so-called "bull-dog head" appearance, but this cephalic œdema passed off, possibly under treatment for this animal was given chrysoidine (*vide infra*).

Some œdema of the fore-legs and paws was noted on February 9th, but it was also transient.

Double corneal opacity was observed on February 12th. Despite treatment the disease progressed and the dog was found dead, stiff and cold on the morning of February 20th.

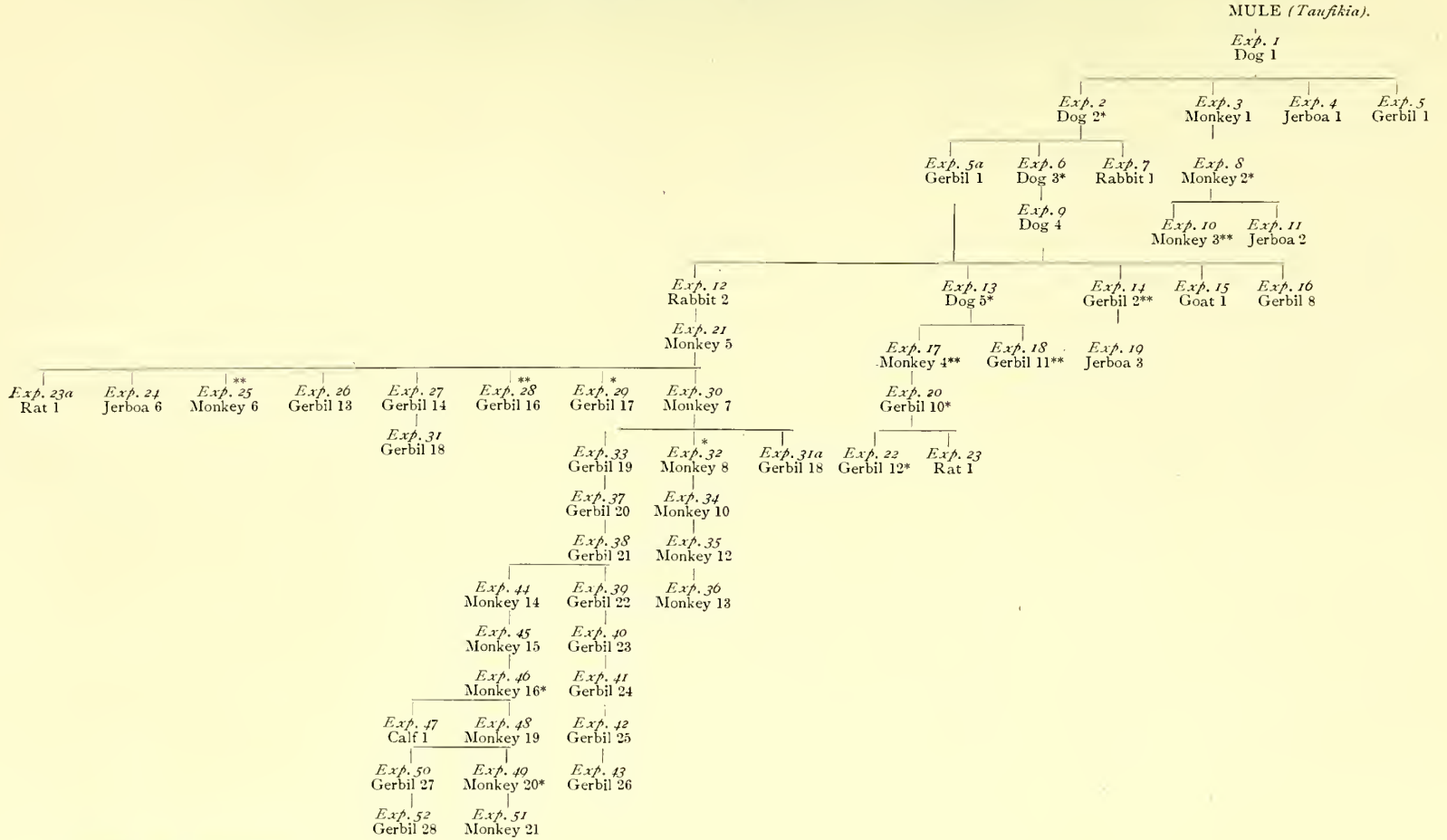
Fig. 68.—Monkey Affected with Trypanosomiasis of Mules

Post mortem the only thing of note was the enlarged spleen, which measured 9 inches (23 c.m.) in length and in which the follicles were enlarged and prominent. A fuller account of this dog will be found later when the chrysoidine treatment is discussed. There was no gastric ulceration. The trypanosomes before treatment was commenced presented no differences from those found in the mule. Both forms were present.

(Descriptions of experiments continued on p. 133.)

Table of Inoculation Experiments

Trypanosomes of Mule Trypanosomiasis



* Treated with chrysoidine.

** Treated with serum.

Note.—The lack of continuity in the series of numbers indicating monkeys, jerboas, and gerbils is due to the fact that other specimens of these animals were being employed in a different series of examinations.

TRYPANOSOME OF MULES

INOCULATION IN DOGS

FIRST PASSAGE

Animal	Date, Source and Mode of Inoculation	Date of Appearance of Parasites in Blood	Number of Parasites seen and Periodicity	Treatment	Result	Post-mortem	Remarks
EXP. 1.—Shilluk Dog 1. Young Animal	June 16, 1905.—Subcut. injection. From Mule (Taufikia) 4 c.c.	Jan. 22, 1905	Swarming; constantly present	Nil	Death	Blood greasy; no gastric ulceration; no enlarged glands; pericardial effusion	Cornealopacity present; fall of temperature; ante-mortem
			SECOND PASSAGE				
EXP. 2.—Dog. 2	Jan. 23.—2 c.c. by subcut. injection. From Dog 1	Found Feb. 4. First Examination	Swarming; constantly present	Chrysoidine (Merck's)	Feb. 19.—Death	Enlarged spleen; no gastric ulceration	Cornealopacity present and transient œdema
			THIRD PASSAGE				
EXP. 6.—Dog 3	Feb. 18—2 c.c. by subcut. injection. From Dog 2	Feb. 25	Swarming; constantly present	Chrysoidine (Merck's)	March 3.—Death	Enlarged liver, spleen, and thymus; nephritis; serous effusions; no gastric ulceration	Slight corneal opacity; possibly overdosed with chrysoidine
			FOURTH PASSAGE				
EXP. 9.—Dog 4	Feb. 26.—5 c.c. by subcut. injection. From Dog 3	March 4.—First Examination	About one per field at first; swarming later; constantly present	Nil	March 23.—Chloroformed in extremis	Enlarged spleen; gastric ulceration; spirilla in blood clot, and ulcerated surface	Cornealopacity; cataract present
			FIFTH PASSAGE				
EXP. 13.—Dog 5	March 18.—2·5 c.c. by subcut. injection. From Dog 4	March 23.—Not present March 22. Incubation 5 days	About 12 per field at first; constantly present	Chrysoidine (Merck's)	April 1.—Chloroformed in extremis	Enlarged spleen, liver and mesenteric glands; gastric congestion. Spirilla present	...

TRYPANOSOME OF MULES

SECOND PASSAGE

INOCULATION IN MONKEYS (*Cercopithecus sabaeus*)

Animal	Date, Source, and Mode of Inoculation	Date of Appearance of Parasites in Blood	Number of Parasites seen and Periodicity	Treatment	Result	Post-mortem	Remarks
EXP. 3.—Monkey 1	Feb. 1.—1 c.c. by subcut. injection. From Dog 1	Feb. 12.—First examination	2 or 3 per field at first then numerous; probably constant	Nil	Feb. 15.—Sudden death	Spleen and liver enlarged; gastric ulceration; altered blood in stomach.	Sudden aggravation of symptoms on Feb. 15; marked somnolence.
			THIRD PASSAGE				
EXP. 8.—Monkey 2	Feb. 15.—2·5 c.c. by subcut. injection. From Monkey 1	Feb. 21.	Swarming. 20 per field; constantly present	Chrysoidine (Merck's)	Mar. 8.—Chloroformed in extremis	Gastric ulceration and ulceration in the cæcum and lower end of ileum; spleen congested.	Marked œdema of scrotum present.

FOURTH PASSAGE

INOCULATION IN MONKEYS—*continued*

Animal	Date, Source, and Mode of Inoculation	Date of Appearance of Parasites in Blood	Number of Parasites seen and Periodicity	Treatment	Result	Post-mortem	Remarks
EXP. 10.—Monkey 3	March 8.—1 c.c. by subcut. injection. From Monkey 2	Mar. 13.—For first time. Incubation 5 days	Few at first; swarming later; constantly present	Serum of Water-Buck	Mar 19.—Chloroformed in extremis	Congestive patches in stomach. Spleen and liver congested.	Convulsions following treatment.
			SIXTH PASSAGE				
EXP. 17.—Monkey 4	March 27.—1 c.c. by subcut. injection. From Dog 5	Apr. 3.—For first time	2 or 3 per field at first; disappeared under treatment	Serum of Water-Buck	May 1.—Found dead	Ulcer in cæcum. Bacterial invasion.	"Tadpole" forms present at one stage.
			SIXTH PASSAGE				
EXP. 21.—Monkey 5	April 10.—1 c.c. by subcut. injection. From Rabbit 2	Apr. 17.—Nil on 15th	1 or 2 per field; numerous later; constantly present	Nil	May 15.—Chloroformed in extremis	Ulceration of stomach, cæcum and small and large intestines; spirilla present.	Typical spirilla only found in smears from ulcers in ileum.
			SEVENTH PASSAGE				
EXP. 25.—Monkey 6	April 24.—1 c.c. by subcut. injection. From Monkey 5	Apr. 29	Considerable, swarming later	Serum of Water-Buck	May 14.—Found dead	Congestion and blood clot in stomach; ulceration in ileum; spirilla seen in fresh smear; not in stained	Cerebral hæmorrhage (supra-cortical)
			SEVENTH PASSAGE				
EXP. 30.—Monkey 7	May 15.—·25 c.c. by subcut. injection. From Monkey 5	May 21.—Examined for first time	Considerable; constantly present	Nil	June 10.—Found dead	General enlargement of mesenteric glands	Corneal opacity present
			EIGHTH PASSAGE				
EXP. 32.—Monkey 8	May 23.—·25 c.c. by subcut. injection. From Monkey 7	June 7.—Examined for first time	6 or 7 per field; constantly present; diminished in number during treatment	Chrysoidine (extra) soluble; ? form; discontinued June 20, 1905	June 24.—Found dead	Ulceration of lower end of small intestine; brain not yellow	Somnolence not well marked
			NINTH PASSAGE				
EXP. 34.—Monkey 10	June 15.—·25 c.c. by subcut. injection. From Monkey 8	June 21.—Examined for first time	Fairly numerous; constantly present	Nil	July 16.—Found dead	Gastric ulceration; congestive patches in ileum; smears negative	...
			TENTH PASSAGE				
EXP. 35.—Monkey 12	Aug. 14.—·5 c.c. by subcut. injection. From Monkey 10	Aug. 24.—Examined for first time	Large infection	Nil	Aug. 29.—Found dead	Apical pneumonia; no special points noted	...
			ELEVENTH PASSAGE				
EXP. 36.—Monkey 13	Aug. 29.—From heart's blood of Monkey 12	Never	...	...	...	...	Failure to infect

ELEVENTH PASSAGE

INOCULATION IN MONKEYS—*continued*

Animal	Date, Source and Mode of Inoculation	Date of Appearance of Parasites in Blood	Number of Parasites seen and Periodicity	Treatment	Result	Post-mortem	Remarks
EXP. 44.—Monkey 14	Aug. 17.—From Gerbil 24	Aug. 22	Severe infection	Nil	Sept. 3.—Chloroformed in extremis	Marked gastric ulceration; no spirilla	Disease ran rather a rapid course.
			TWELFTH PASSAGE				
EXP. 45.—Monkey 15	Sept. 3.—·25 c.c. by subcut. injection. From Monkey 14	Sept. 15.—First examination	Considerable; none found on Sept. 30	Nil	Oct. 14.—Found dead	Ulceration and inflammatory induration in small and large intestine	...
			THIRTEENTH PASSAGE				
EXP. 46.—Monkey 16	Oct. 5.—·5 c.c. by subcut. injection. From Monkey 15	Oct. 17.—First examination	Swarming; constantly present	Chrysoidine (Merck's)	Oct. 22.—Died	Liver and spleen enlarged and congested; no ulceration	Brain and spinal cord stained slightly yellow
			FOURTEENTH PASSAGE				
EXP. 48.—Monkey 19	Oct. 22.—From heart's blood of Monkey 16	Oct. 28.	Large number present; constantly present	Nil	Nov. 15.—Died	In bone marrow; L.-D. forms present; no ulceration	L.-D. forms; probably the young forms of Lingard
			FIFTEENTH PASSAGE				
EXP. 49.—Monkey 20	Nov. 15.—From heart's blood of Monkey 19	Nov. 29.—Examined for first time	Considerable	Chrysoidine (Merck's)	Chloroformed in extremis; death probably hastened by chrysoidine	Mesenteric glands hæmorrhagic; L.-D. forms present	Brain, spinal cord and nerve trunks a brilliant yellow
			SIXTEENTH PASSAGE				
EXP. 51.—Monkey 21	Nov. 21.—·5 c.c. injected subcut. From Monkey 20	...	...	...	...	...	...

TRYPANOSOME OF MULES.

INOCULATION IN JERBOAS (*Jaculus Gordoni*) SECOND PASSAGE

Animal	Date, Source, and Mode of Inoculation	Date of Appearance of Parasites in Blood	Number of Parasites seen and Periodicity	Treatment	Result	Post-mortem	Remarks
EXP. 4.—Jerboa 1	Feb. 3.—Few drops by subcut. injection. From Dog 1	Never	..	Nil	Death in 48 hours	No evidence of trypanosome infection	Harboured *Hæmogregarina Balfouri* (Laveran)
			FOURTH PASSAGE				
EXP. 11.—Jerboa 2	Feb. 22.—A few drops by subcut. injection. From Monkey 2	Found post-mortem on Feb. 28; not present Feb. 26	...	Nil	Feb. 28—Found dead	Gastric ulceration; trypanosomes found in blood from heart	Ditto
			SIXTH PASSAGE				
EXP. 19.—Jerboa 3	March 22.—A few drops by subcut. injection. From Gerbil 2	March 25—For first time	4 or 5 per field; constantly present	Nil	March 28—Death	Gastric ulceration; curious "ruddy" forms in stomach smears	Ditto

INOCULATION IN RABBITS — THIRD PASSAGE

Animal	Date, Source and Mode of Inoculation	Date of Appearance of Parasites in Blood	Number of Parasites seen and Periodicity	Treatment	Result	Post-mortem	Remarks
Exp. 7.—Rabbit 1	Feb. 18.—5 c.c. by subcut. injection. From Dog 2	Never	...	Nil	March 3—Died during night	Decomposed; bacterial invasion; no trypanosomes in smears	Only symptom was progressive emaciation
			FIFTH PASSAGE				
Exp. 12.—Rabbit 2	March 4.—1·5 c.c. by subcut. injection. From Dog 4.	April 4—For first time	1 per cover-slip at first; increased in number later	Nil	April 11—Killed by accident	Decomposed; bacterial invasion; no trypanosomes in smears	Marked conjunctivitis and blepharitis; falling out of hair round the eyes
INOCULATION IN GOAT			FIFTH PASSAGE				
Exp. 15.—Goat 1	March 21.—1 c.c. by subcut. injection. From Dog 4	March 30—For first time	1 per cover slip; never more than 2 present; often absent	Nil	May 31—Chloroformed in extremis	Increase of cerebro-spinal fluid which was cloudy; enlarged mesenteric glands	Myelocytes and eosinophile myelocytes present
INOCULATION IN RAT (*Mus decumanus*)			SEVENTH AND EIGHTH PASSAGES				
Exp. 23.—Rat 1	April 12.—1 c.c. From Gerbil 10.	Never	...	...	...	...	Failure in both experiments
Exp. 23*a*.—Rat 1	April 22—1 c.c. From Monkey 5	Never	...	...	April 23—Found dead	Bacterial invasion	
INOCULATION IN CALF			FOURTEENTH PASSAGE				
Exp. 47.—Calf 1	Oct. 10—1·5 c.c. by subcut. injection. From Money 16	Oct. 23—For first time	A few present; vanished later	...	Dec. 10—Animal well and fat	...	No infection save temporarily

TRYPANOSOME OF MULES.

INOCULATION IN GERBILS (*Gerbillus pygargus*) SECOND PASSAGE

Animal	Date, Source and Mode of Inoculation	Date of Appearance of Parasites in Blood	Number of Parasites seen and Periodicity	Treatment	Result	Post-mortem	Remarks
Exp. 5.—Gerbil 1	Feb. 1.—A few drops by subcut. injection From Dog 1	Never	...	...	...	...	Failure to infect
Exp. 5a.—Gerbil 1	Later from Dog 2 and Dog 3; second and third passages	?	Swarming; constantly present	Nil	Death	No gastric ulceration	Error in inoculation
			FIFTH PASSAGE				
Exp. 14—Gerbil 2	March 4.—A few drops by intraperitoneal injection. From Dog 4	Mar. 7.—For first time	A few at first; then swarming; constantly present	Serum of Water-Buck	Mar. 24.—Found dead	Stomach decomposed; spleen enlarged	Slight illness compared with intensity of infection
			FIFTH PASSAGE				
Exp. 16.—Gerbil 8	March 18.—A few drops by intraperitoneal injection. From Dog 4	Mar. 22.—For first time	Fairly numerous; constantly present	Nil	Apr. 3.—Found dead	Areas of congestion in stomach; curious involution forms in smears	Granular basophilia of erythrocytes

INOCULATION IN GERBILS *(continued)*

SIXTH PASSAGE

Animal	Date, Source and Mode of Inoculation	Date of Appearance of Parasites in Blood	Number of Parasites seen and Periodicity	Treatment	Result	Post-mortem	Remarks
Exp. 18.—Gerbil 11	March 26.—A few drops by subcut. injection. From Dog 5	Mar. 29—For first time	Fairly numerous; constantly present	Serum of Water-Buck	Apr. 3.—Found dead	Altered blood in stomach; congestion; bacterial invasion; no trypanosomes in smears	...

SEVENTH PASSAGE

Exp. 20.—Gerbil 10	April 4.—25 c.c. by subcut. injection. From Monkey 4	Apr. 8.—For first time	Fairly numerous; mostly long forms at first; varied under treatment	Chrysoidine (Merck's)	Apr. 19.—Found dead	Bacterial invasion; success negative	...

EIGHTH PASSAGE

Exp. 22.—Gerbil 12	April 10.—A few drops by subcut. injection. From Gerbil 10	April 12.—For first time	One per cover slip at first; swarming by April 15	Chrysoidine (extra) soluble?	April 20.—Found dead	L.-D. forms in liver. Altered trypanosomes in smears	Brain and sp.-cord stained yellow

SEVENTH PASSAGE

Exp. 26.—Gerbil 13	May 4. — A few drops by subcut. injection. From Monkey 5	May 8.—Examined for first time.	Considerable number.	Nil	May 10.—Found dead	Bacterial invasion	Decomposed

SEVENTH PASSAGE

Exp. 27.—Gerbil 14	May 4. — A few drops by subcut. injection. From Monkey 5	May 8.—Examined for first time	Considerable number	Nil	May 21.—Chloroformed for culture work	No ulceration; many parasites, long and short forms in heart's blood	Cultures on blood agar failed

SEVENTH PASSAGE

Exp. 28.—Gerbil 16	May 11.—A few drops by subcut. injection. From Monkey 5	May 16.—Examined for first time	Only a few present	Serum of Water-Buck; begun May 21	May 21.—Chloroformed in convulsions 6 p.m.	No ulceration; spleen and kidneys enlarged; degenerated trypanosomes or nil in smears	Was there liberation of toxines from trypanosome destruction?

SEVENTH PASSAGE

Exp. 29.—Gerbil 17	May 11. — A few drops by subcut. injection. From Monkey 5	May 16.—Examined for first time	Numerous; constantly present	Chrysoidine (Extra) soluble?	May 22.—Died	Spleen enlarged; bacterial invasion	Brain and spinal cord a brilliant yellow

EIGHTH PASSAGE

Exp. 31.—Gerbil 18	May 21.—Inoculated from Gerbil 14 by scratch inoculation	Never	...	...	Failure to infect	...	..
Exp. 31*a*.—Gerbil 18	May 27. — A few drops by subcut. injection. From Monkey 7	June 4.—Examined for first time	Swarming	Nil	? Record lost	...	...

Inoculation of Gerbils *(continued)*

Eighth Passage

Animal	Date, Source and Mode of Inoculation	Date of Appearance of Parasites in Blood	Number of Parasites seen and Periodicity	Treatment	Result	Post-mortem	Remarks
Exp. 33.—Gerbil 19	May 27. — A few drops by subcut. injection From Monkey 7	June 4.—Examined for first time	Fairly numerous at first; swarming later	Nil	June 30.—Chloroformed in extremis	Spleen enlarged	...
			Ninth Passage				
Exp. 37.—Gerbil 20	June 28.— 25 c.c by subcut. injection. From Gerbil 19	July 7.—Examined for first time	Not many present	Nil	Aug. 3.—Found dead	No ulceration	...
			Tenth Passage				
Exp. 38.—Gerbil 21	July 29.—5 c.c. by subcut. injection. From Gerbil 20	Aug. 2.—Examined for first time	No note at first; swarming later	Nil	Aug. 19.—Found dead	Decomposed	...
			Eleventh Passage				
Exp. 39.—Gerbil 22	Aug. 8.—25 c.c. subcut. by injection. From Gerbil 21	Aug. 17.—Examined for first time	Swarming	Nil	Aug. 28.—Died	Spleen enlarged; no ulceration	...
			Twelfth Passage				
Exp. 40.—Gerbil 23	Aug. 20. — By subcut. injection. From Gerbil 22	Aug. 22.—For first time	Slight infection at first	Nil	Sept. 13.—Died	Nothing special noted	...
			Thirteenth Passage				
Exp. 41.—Gerbil 24	Sept. 5. — By subcut. injection. From Gerbil 23	...	...	...	Sept. 20.—Died	...	...
			Fourteenth Passage				
Exp. 42.—Gerbil 25	Sept. 14.—By subcut. injection. From Gerbil 24	...	...	...	Oct. 6.—Died	...	...
			Fifteenth Passage				
Exp. 43.—Gerbil 26	Sept. 21.—By subcut. injection. From Gerbil 25	Never	...	...	Failure to infect	...	...
			Fifteenth Passage				
Exp. 50.—Gerbil 27	Nov. 8 — By subcut. injection. From Monkey 19	Nov. 19.—Examined for first time	Numerous	Nil	Dec. 10.—Died	Spleen enlarged	...

Exp. 3. Monkey 1.—(*Cercopithecus sabæus*, or green grivet monkey.)

February 1st. Inoculated subcutaneously with 1 c.c. blood from Dog 1.

February 12th. Trypanosomes found.

February 15th. Death occurred.

The symptoms presented were those of progressive anæmia, emaciation and weakness. The mucous membranes became very blanched. Towards the end there was marked somnolence, the monkey frequently taking up the position shown in Fig. 68, which is very like the photographs of the monkeys inoculated with T. gambiense, and figured in the

Uganda Reports of the Royal Society's Commission. In this monkey the symptoms underwent a sudden aggravation on February 13th, and death occurred rather suddenly. Trypanosomes swarmed in the blood, but none of the long, thin, whip-like forms were seen. The long forms all seemed to have increased in breadth, probably as a preliminary to longitudinal division. Typical short forms were present.

Post-mortem.—Spleen and liver both enlarged. Hæmorrhagic ulceration present in the stomach, which contained glairy mucus and altered blood. Unfortunately smears were not made. There was no pericardial or pleural effusion.

In a smear of a mixture of blood and cerebro-spinal fluid obtained from one of the fossæ of the skull after removal of the brain, trypanosomes, numerous bacteria, and a short, stout spirillum were found. The last looked like two thick cholera vibrios joined end to end, was rounded at the extremities, and quite unlike the spirillum found in gastric ulceration (*vide infra*). The animal had been dead some hours before the examination could be made.

Exp. 4.—Jerboa 1 (*Jaculus gordoni*). Inoculated subcutaneously with a few drops of blood from Dog 1 on February 3rd, 1905. This animal, which harboured the hæmogregarine already described, became very ill after forty-eight hours and was chloroformed. No evidence of infection with trypanosomes was found post-mortem.

Exp. 5.—Gerbil 1 (*Gerbillus pygargus*, the common desert mouse). February 3rd. Inoculated subcutaneously with a few drops of blood from Dog 1. This mouse was examined several times with negative results. At a later period it was re-inoculated from Dog 2, and still later from Dog 3, owing to an error. (*vide* table).

It developed trypanosomiasis and died during the night. Sluggish and degenerating trypanosomes were found in the heart's blood. There was no gastric ulceration. The experiment was unsatisfactory owing to the multiple inoculations performed. The blood showed both forms of trypanosome, and in this case, as in that of other *gerbils*, there was noticed an increase in length in that part of the long trypanosomes extending behind the centrosome (Fig. 69). In some instances the measurement from the posterior end to the centre of the centrosome was as much as 4·2 μ approaching the appearance found in *T. Lewisi*. This portion of the body in *gerbils* is occasionally curved.

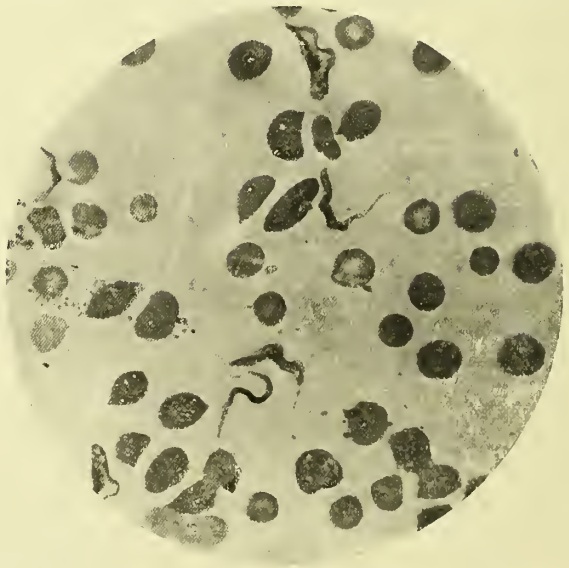


Fig. 69.—Forms in Gerbil. Note long posterior end (× 833 diam.)

Exp. 6. Dog 3.—Inoculated subcutaneously on February 18th, with 2 c.c. blood from Dog 2. Trypanosomes were found in the blood on 25th February, 1905. This dog received intravenous injections of chrysoidine, and will be mentioned later. Death occurred on March 3rd. Slight corneal opacity had been noticed during life. At the autopsy the spleen was found to be enlarged, and the follicles prominent on the surface. The liver was enlarged and congested.

The kidney exhibited signs of subacute nephritis, the capsule being slightly adherent.

There was no gastric ulceration.

In the thorax the pericardium was found much distended with serous effusion, and the heart muscle was very flabby. The thymus gland was enlarged.

Although the post-mortem was performed immediately after death, and smears made from all the organs mentioned, no trypanosomes were found—a point to which reference will be made when experimental treatment is considered (p. 155).

Exp. 7. Rabbit 1.—Inoculated subcutaneously with 5 c.c. blood from Dog 2, on 18th February, 1905.

Blood examined 28th February, 1905, with negative results.

This rabbit became emaciated, but showed no other symptoms of the disease. Trypanosomes were at no time found in its blood, nor was subcutaneous œdema present. It died during the night of March 3rd, and was found already somewhat decomposed on the morning of the following day. Post-mortem digestion of the stomach had set in together with a general bacterial invasion of the tissues. No trypanosomes were found post-mortem.

I am inclined to think this animal died of trypanosomiasis, and that more frequent examination of the blood would have revealed the presence of the parasites during life.

Exp. 8. Monkey 2.—Inoculated subcutaneously on February 15th, with about 2·5 c.c. blood from Monkey 1.

Blood examined, 21st February, 1905, when it was found to be swarming with trypanosomes of both forms, there being 15 or 20 to each microscopic field. This monkey was also treated with chrysoidine (*vide* p. 155).

After running a somewhat peculiar course it was found in extremis and chloroformed on March 8th.

Post-mortem.—Swelling and œdema of the scrotum present in a marked degree. Extreme anæmia of the mucous membranes. Gastric ulceration present, and ulceration at the lower end of the ileum and in the cæcum. In the stomach a flat blood clot was found adherent to the mucous membrane towards the pyloric end. On removing it a red congestive stippling was found. Similar congestive patches were present in the ascending colon. The stomach and intestines were preserved for colour museum specimens, and smears were not taken. The spleen was firm and congested; the liver showed nothing beyond slight congestion; there was early nephritis present. The brain and cerebro-spinal fluid were examined but nothing peculiar was noted.

Exp. 9. Dog 4.—Inoculated subcutaneously with 5 c.c. blood from Dog 3 on 26th February, 1905.

Blood examined, March 4th, 1905, when trypanosomes found, about one per field. The temperature taken at noon on this day was 104·8 F. Both forms of parasite were present in the blood, and were very lively and active in their movements. This dog was not treated so that its symptoms may be described here.

Corneal opacity was first noticed on March 11th. It attacked the left eye, the other remaining unaffected at first. On March 22nd, both eyes were found affected and an opacity of the lens of the left eye was noted. The other symptoms exhibited were the customary anæmia, emaciation and drowsiness. There was no œdema. At all times trypanosomes in large numbers and of both kinds were found in the peripheral blood.

On March 23rd, the dog was found collapsed and cold. There was rigidity of the limbs, and the respirations were laboured and rapid.

About twenty trypanosomes per field were found, nearly all of the short form, and it

was noticed that their movements were sluggish. As it was evident the dog would die during the night it was chloroformed and an autopsy performed immediately.

The temperature record from the day when trypanosomes were found in the blood was as follows:

104·8°., 105·8°., 105·8°., 103·4°., 100·5°., 103·5°., 105°., 103·40°., 103°., 102·4°., 103·8°., 104·3°., 103·6°., 102·4°., 102·8°., 103·5°., 103·6°., 103°., 103·2°., 101·6° F.

Gorged female ticks (*Rhipicephalus sanguineus*) were present on this dog, and the blood from their stomachs was examined on several occasions, but trypanosomes were never found.

Post-mortem.—Very little gelatinous exudation present, emaciation extreme. Muscles pale and flabby. Eyes exhibited double corneal opacity. A complete soft cataract was present in the lens of the left eye—a symptom which I think has not hitherto been noted. Time unfortunately did not admit of an examination of the brain.

Heart large and flabby, with pale muscular tissue.

Lungs blanched, dry and bloodless.

Spleen: length 7½ in.; marked enlargement of follicles, so that the surface of the congested, but dry and firm organ, was rough to the touch, and exhibited numerous small elevations.

Liver.—Large, fatty and congested.

Stomach.—The vessels passing to and from the lesser curvature and distributed externally upon the stomach walls were greatly engorged. The organ was full of dark brown very tenacious mucus. The streaks of coffee-coloured mucus owed their hue to altered blood.

A large ulcer found at the junction of the smooth and rugose portions of the mucous membrane. Its length was ¾ inch, its breadth ⅜th inch. Edges of ulcer irregular and soft, its surface was covered by a slightly adherent blood clot. In addition to this large erosion seven small hæmorrhagic looking ulcers were found scattered about throughout the rugose portion of the mucous membrane. One or two of these looked as though they were undergoing a healing process. In no instance were the tiny central holes, mentioned as having been observed in the ulcerated areas of the stomach of an ox, present in this case.

Smear preparations were made both from the blood clot covering the surface of the large ulcer and also from the ulcerated surface after removal of the clot. These were stained by the Leishman-Romanowsky method, and in both instances large numbers of spirilla were found (Plate XIII., Fig. *c*). These spirilla, which were somewhat blunt at the ends, measured from 2·8 μ to 7·7 μ in length, and possessed from four to seven short undulations. Nothing like Leishman-Donovan bodies were seen though they were carefully looked for, but trypanosomes of the short form, which stained badly and appeared degenerated, were present in small numbers. No involution forms were observed.

Intestines.—They were searched throughout their whole length but no ulceration was detected.

The stools were dark, liquid and offensive. A smear was made of them, which, when stained, showed in addition to bacteria, numbers of spirilla. These latter, however, presented an appearance somewhat different from those mentioned above. Their undulations were longer so that they had not the saw-edge appearance shown in Fig. *c*, and they were more pointed at the ends. They may have been merely altered forms.

There were also present thick spirillar form like two vibrios attached end to end, very similar to those found in Monkey 1.

Kidneys.—These exhibited a subacute nephritis, and the capsules were slightly adherent.

Bone-marrow.—Not examined.

Curiously enough in smears made from the splenic pulp there was not a vestige of a trypanosome to be seen, while in the liver specimens both forms were present in abundance.

Exp. 10. Monkey 3.—(*Cercopithecus sabæus*) weight 2·7 kilos. Inoculated subcutaneously with about 1 c.c. blood from Monkey 2 on March 8th. Peripheral blood examined each day thereafter and trypanosomes in small numbers found for the first time on March 13th.

The incubation period was, therefore, just about five days.

March 14th.—Both long and short forms were seen, the former greatly preponderating. In the cover-glass preparation they appeared to be of exceptional length and extremely active. On staining in the usual way no increase in length was manifest. Probably some shrinking had taken place during the preparation of the specimen. Both forms were well seen but the short ones were very much in the minority.

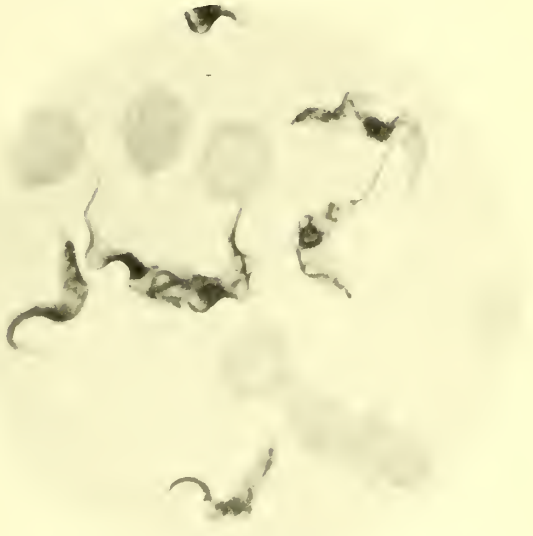


Fig. 70.—Dividing Vacuolated Forms, Monkey 3 (× 1750 diam.).

A considerable number of very broad trypanosomes were present. These were probably parasites in the stage prior to longitudinal division (Fig. 70). Some granules were noted in the short forms, and in one of these latter the nucleus was observed to be at the junction of the middle and posterior thirds.

March 18th.—The monkey was found to be very ill. It was lying in its cage in a semi-prone condition.

The blood on examination was found to be swarming with parasites, short forms being now as numerous as the broad forms previously mentioned.

This monkey was then treated with blood serum injections and its further history will be considered under the heading Treatment.

Being in extremis it was chloroformed on the following day (March 19th). It had lost half a kilo in weight.

Post-mortem.—*Stomach*, congestive patches towards the pylorus. No ulceration.

Intestines.—Normal.

Mesenteric glands enlarged, giving a beaded appearance to the mesentery.

Spleen.—Weight, 23 grams. Large, congested. In a smear from the cut surface of the organ curious involution forms were found, one closely resembling the figure of a dead

and altered trypanosome, given in the plate illustrating the article by M. Thiroux* on *T. Paddæ*. These forms will be more fully described when the serum treatment is considered.

Liver.—Congested

Brain.—Slight thickening of the meninges and congestion. The cerebro spinal fluid showed no peculiar forms.

Bone-Marrow taken from the femur showed no trypanosome forms whatever.

It may be mentioned here that the method of preparing smears of marrow recommended by Price Jones† has been employed and has proved satisfactory.

Exp. 11. Jerboa 2. The blood of this animal, on examination before inoculation, was found to harbour hæmogregarines.

It was inoculated on February 22nd with a few drops of blood from Monkey 2.

February 26th. Blood examined. No trypanosomes found.

February 28th. Found dead and cold.

Ulceration of the stomach present. No smears made as specimen kept for colour preparation.

Trypanosomes found in the heart's blood. Involution forms present.

Exp. 12. Rabbit 2 ♀. *March 4th.* Inoculated subcutaneously with about 1·5 c.c. blood from Dog 4. This rabbit had its blood frequently examined, with and without being centrifuged, up till the end of March, but no trypanosomes were found nor were any symptoms of trypanosomiasis visible save a slight but progressive emaciation. About the beginning of April it was noticed that the rabbit's eyes were becoming infected and in a few days a similar condition to that described and figured by Musgrave and Clegg‡ as occurring in rabbits after inoculation with the horse trypanosome of the Philippines was apparent, namely, a severe blepharitis with some conjunctivitis, a narrowing of the palpebral fissure, œdema of the eyelids and falling out of the hairs surrounding the eyes.

April 4th. Blood from ear examined. After prolonged search one trypanosome (a long form) found in the cover glass preparation. A considerable number of parasites were present in a drop of fluid taken from the œdematous tissue of the lower eyelid after a slight incision had been made. No trypanosomes were present in the thick, gummy discharge from the eyelid.

April 8th. Blood film stained. A considerable number of trypanosomes found. Both forms present.

On this day it was noticed that the respiration had become rapid and wheezing, somewhat of an asthmatic type, possibly due to a congestive condition of the nasal mucous membranes.

April 7th. Baldness very marked round the eyes. Respirations rapid, wheezy and laboured. Animal looks very ill but takes food freely.

April 10th. Rabbit in much the same condition.

April 11th. Animal unfortunately killed during the night by a mongoose, which escaped from a cage in the fly-proof house. Found stiff, cold and decomposing. Autopsy performed as soon as possible, but bacterial invasion of the tissues had occurred, and in smears made

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* Am. de l'Inst. Pasteur, Paris, 1905. Vol. XIX., p. 65. † Brit. Med. Jour., London, Feb. 25th, 1905, p. 409.

‡ Trypanosoma and Trypanosomiasis with special reference to Surra in the Philippine Islands. No. 5. Publications of Bureau of Gov. Lab. Manila, 1903.

from spleen, liver, stomach surface, blood of vessels of stomach, lung's and heart's blood, no trace of trypanosome infection was detected.

There was no ulceration of the stomach, but the gastric vessels were engorged. At one point there was a congestive patch on the mucous membrane.

Exp. 13. Dog 5. A pariah suggesting tuberculosis.

March 18th. Inoculated subcutaneously with about 2·5 c.c. blood from Dog 4.

March 22nd. Blood examined. No trypanosomes present.

March 23rd. Blood examined. Trypanosomes present, about 12 per microscopic field, nearly all long forms and very lively. The incubation period was, therefore, 5 days. This dog was treated by injections of chrysoidine intravenously and its case thus falls to be described when treatment is considered (p. 156) but the post-mortem examination was very interesting and the results may be here described.

April 1st. Animal in a dying condition in the evening, chloroformed and kept in the ice chest till the following morning.

April 2nd. Autopsy performed, no external signs except emaciation.

Stomach.—The vessels passing to and from the lesser curvature and distributed externally upon the stomach well were much engorged. The gastric contents consisted of altered blood and glairy mucus. There was no ulceration, but along the ridges of several of the rugæ there were areas of congestion presenting a dull red œdematous appearance. Smears from these shewed spirilla similar in every respect to those shewn in Fig. *c*.

Smears from the stomach contents also shewed spirilla. No trypanosome forms present.

Intestines.—Full of altered blood and mucus. Peyer's patches congested, exhibiting an appearance somewhat like that seen in early enteric, approaching to the "shaved beard" aspect. There was no ulceration.

A smear from the surface of a congested patch shewed neither spirilla nor trypanosomes.

There was great enlargement of the mesenteric glands, especially in the appendicular area where there was a regular bunch of them, the largest being 3 inches in length. On section they shewed no caseation, but as they may prove to be tubercular, they were put aside for microscopical examination.

Large Intestine.—Wholly unaffected.

Spleen.—Large and congested smear. No signs of trypanosomes.

Liver.—Also large and congested. Smear shewed numerous curious involution forms probably due to the treatment adopted.

Kidneys.—Slight congestion.

Brain.—Engorgement of superficial vessels. Some excess of cerebro-spinal fluid. Smear of fluid made. No trypanosomes present.

Bone marrow.—Dark red in colour. Smear, negative.

Lungs.—Smear, negative.

Heart's blood.—Smear, negative.

The absence of trypanosomes in all the smear preparations except the liver is a peculiar and interesting fact.

Compare with the findings in Exp. 6.

Exp. 14. Gerbil 2.

March 4th. Inoculated intraperitomally with a few drops of blood from Dog 4.

March 7th. Trypanosomes found for the first time in blood taken from the tail.

March 10th. Animal ill. Eyes partially closed. Head held low. Coat roughened, respirations rapid. The blood was swarming with trypanosomes, chiefly long forms, and in this case the prolongation of the protoplasm of the parasites behind the centrosome was very marked.

March 16th. Blood literally alive with parasites. There seemed to be as many trypanosomes as there were red blood corpuscles. They were extremely active, and a great variety of forms were seen due to the propagation which was proceeding. Dividing forms, both long and short, were numerous, as were broad forms and forms united by their posterior ends (Fig. 71).

Some of the parasites presented a very curious aspect, their undulating membranes being of great size.

Considering the great infection, the gerbil showed remarkably little sign of illness. Treatment with the blood serum of a water buck was begun on March 20th, so that only the post-mortem signs need be here considered.

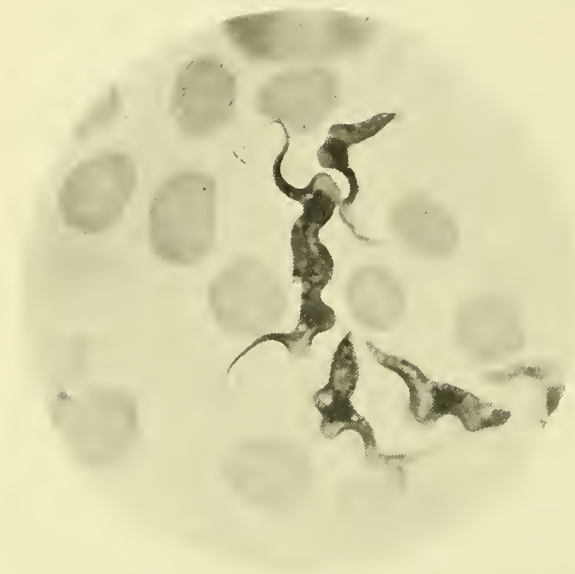

Fig. 71.—Forms with their Posterior Ends in Contact (× 1750 diam.)

The animal was found dead on March 24th.

Unfortunately the stomach had undergone decomposition. The spleen was enlarged, its length being 1⅛th inches, the total length of the gerbil, excluding the tail, being 4 inches. Nothing else of interest was noted. The heart's blood and liver showed degeneration forms of trypanosomes.

Smears of the spleen, brain, spinal cord, bone marrow and intestines, showed nothing peculiar.

Exp. 15. Goat 1♀. Weight, 13 kilos. March 21st. Inoculated subcutaneously with 1 c.c. blood from Dog 4.

The blood was examined every day with negative results down to March 30th. On that day one trypanosome, a long form, was found in the whole cover glass preparation. The goat presented no sign of illness. Thereafter the blood remained free till April 16th, when two trypanosomes were found in a cover-slip preparation. They seemed to be long forms. At this time the animal showed no signs of emaciation. Nothing was found in the blood examined on April 20th. After this date it was noted that the animal was beginning to get thinner. Not till June 20th was any sign of weakness exhibited. On that date the goat was found lying down. The appetite was fair. No enlarged cervical glands could be detected. Trypanosomes, as before, were very scarce in the peripheral blood. On June 22nd the goat weighed 9·8 kilos; on May 31st, when in extremis, 8·3 kilos. No parasites in peripheral blood. The animal was extremely emaciated. There was no œdema and no affection of the eyes. Chloroform was administered, and a post-mortem performed immediately, but little of interest was noted. There was, however, a marked increase of cerebro-spinal fluid which, moreover, was cloudy, and on standing deposited much sediment. The brain was œdematous. There was no ulceration in the stomach or intestines. The

liver was congested, but the spleen looked normal. The mesenteric glands were enlarged and one of them was hæmorrhagic. Bone-marrow, pale. Lungs, anæmic and retracted. Smears were made from the heart's blood, liver, spleen, intestines, bone-marrow, glands and cerebro-spinal fluid. In the last mentioned only were trypanosomes found—a few unaltered, apparently long forms, being present, but they did not present a characteristic appearance. In the heart's blood myelocytes and eosinophile myelocytes were present.

Exp. 16. Gerbil 8. March 18th. Inoculated intraperitomally with a few drops of blood from Dog 4.

Blood examined daily and found to be infected on March 22nd. Incubation period, $3\frac{1}{2}$ days.

Trypanosomes of both forms fairly numerous. No "tadpole" forms, like those described in rats by Dutton and Todd, found. Punctate basophilic degeneration of the red cells was present. It is common in gerbils, as is polychromatophilia.

Trypanosomes were constantly present in the blood in fair numbers till death occurred on April 3rd. The symptoms were drowsiness and progressive emaciation, no œdema, *April 3rd.* Animal found dead in the morning.

Post-mortem.—A bunch of nematodes found in the stomach. That organ contained altered blood and thick, tenacious mucus. There were congested points on the surface of the mucous membrane which looked as though they might have gone on to ulceration.

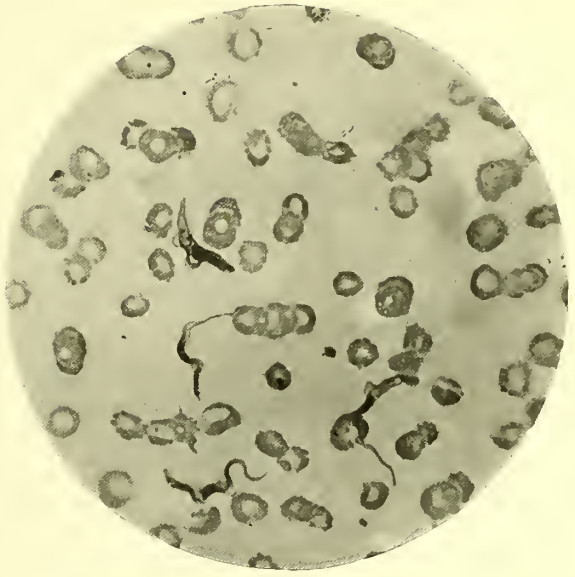

Fig. 72.—Forms seen in Blood. Monkey 4 (× 833 diam.).

Smears were made from these small areas. In these no spirilla were found, but some very curious forms of trypanosomes were present.

Thus there was a pear-shaped form, the bulbous part almost wholly surrounded by the looped free edge of an undulating membrane which sprang from a centrosome situated close to the root of the long flagellum. The protoplasm was slightly granular, and there was a distinct vacuoloid area beside the centrosome. Another quaint form was fish-shaped, with a thick, short, blunt anterior extremity, a well-marked centrosome, vacuoloid area and a nucleus which had lost its differential staining, and was indefinitely marked. The whole parasite stained in a peculiar manner and was probably an involution form.

In addition to these, tiny forms shaped like trypanosomes were seen. I am doubtful if these are parasites at all.

Their protoplasm stained a faint violet-pink or ruddy hue, quite a peculiar colour while the centrosomes and nuclei were stained deep Romanowsky red. They possessed no visible flagella and were fairly numerous. Plate XIV.; Fig. *f.*

Faintly staining forms, with their posterior ends in contact, were also seen.

Heart.—Ordinary trypanosomes, both forms present.

Liver, Spleen and Lungs.—Smears showed ordinary trypanosomes and spherical and oddly-shaped involution forms. The spleen was 1 inch in length, the gerbil from snout to root of tail 4 inches.

Cerebro-Spinal Fluid.—Many trypanosomes were found ; a bird-shaped form with a nucleus undergoing segmentation was noted. Plate XIV., Fig. *c*.

Bone-marrow.—No trypanosomes present.

Exp. 17. Monkey 4 (*Cercopithecus sabæus*). Weight 2·4 kilos.

March 27th. Inoculated subcutaneously with 1 c.c. blood from Dog 5.

Trypanosomes of both kinds found for the first time on April 3rd.

April 5th. Treatment with blood serum commenced (*vide* p. 166).

Exp. 18. Gerbil 11. No basophilia present in the erythrocytes.

March 26th. Inoculated subcutaneously with a few drops of blood from Dog 5.

March 29th. Both forms of trypanosome present (Fig. 72). This animal was also treated with serum (*vide infra*).

The animal was found dead on April 3rd. Its stomach contained nematodes and altered blood.

There was some congestion at the cardiac end.

Unfortunately a bacterial invasion of all the tissues had occurred, and the smears made showed no trypanosome infection.

The spleen measured $1\frac{1}{8}$ inches in length while the gerbil from snout to root of tail was $4\frac{1}{4}$ inches.

Exp. 19. Jerboa 3. The blood contained a few hæmogregarines.

March 22nd. Inoculated subcutaneously with a few drops of blood from Gerbil 2.

March 25th. Trypanosomes present, four or five per microscopic field. Very typical long and short forms. Emaciation set in, and the jerboa died on the morning of March 28th.

An autopsy was at once performed.

Stomach.—Ulcerated, there being several small hæmorrhagic erosions, and, in addition, tiny areas of congestion. There was the same sticky, coffee-coloured mucus present, as in Dog 4 and the other cases quoted.

Smears were made both of the blood clot covering the largest ulcer, and from the surface of the ulcer itself.

The same condition of things was found in both, *i.e.*, (*a*) ordinary short trypanosomes ; (*b*) involution forms of various kinds ; (*c*) the curious small "ruddy" forms which were present, in Gerbil 8 (Exp. 16). The intense staining of their relatively large nuclei, and centrosomes was again evident. Some trypanosomes looked as though they had undergone involution, nucleus and centrosome remaining well marked, but the general shape having entirely altered. A number of these forms looked extremely like Leishman bodies, but in none of them were the short chromatin rods so characteristic of the parasites of Cachexial Fever seen. A spherical dot, however, was present, and these are evidently the young forms described by Lingard.*

The tiny "ruddy" forms occurred in groups or singly. The largest found of a typical trypanosome shape measured 9·8 μ. in length, by 2·8 μ. in breadth at the broadest part, *i.e.*, the nucleus. Plate XIV. ; Fig. *f*.

Heart.—Blood ; trypanosomes present. Both forms seen, also involution forms like those found in the stomach. None of the small "ruddy" kinds seen.

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* *Indian Med. Gazette*, Calcutta, Sept. and Oct., 1905.

Lung, Bone-marrow and Liver also showed altered trypanosome forms.

Spleen and Brain.—No trypanosomes present.

Exp. 20. Gerbil 10.—Weight 34 grams. This gerbil's blood contained some red cells infected in the manner to be described.

April 4th. Inoculated subcutaneously with ·25 c.c. blood from Monkey 4.

April 8th. Trypanosomes, mostly long forms, found in the blood. Some short forms showing granules were also present.

April 8th. Treatment with chrysoidine begun (*vide* p. 157).

Exp. 21. Monkey 5. (*Cercopithecus sabæus*).

April 10th. Inoculated with 1 c.c. blood from Rabbit 2 (Exp. 12).

April 15th. Blood examined. Nil.

April 17th. Trypanosomes present. One or two per field. Mostly long forms.

April 22nd. Many parasites seen. Dividing forms noticed.

April 24th. Conditions the same as on April 22nd.

May 8th. The animal has been getting thin. Mucous membranes somewhat anæmic but blood of a good colour. Four or five trypanosomes seen in most fields. Fæces examined microscopically. No spirilla or trypanosomes found. A few red cells and a good many leucocytes present.

May 15th. Monkey very ill and evidently nearing its end. Appetite still preserved. Trypanosomes not so numerous in the blood as formerly. Some apparently degenerated forms showing vacuolation. Chloroformed at 3.15 p.m. and autopsy performed at once.

Body emaciated. No scrotal œdema or eye infection. Mucous membranes markedly anæmic.

Heart's blood.—Both forms present. The long trypanosomes extremely active, rapidly traversing the field, and moving almost like spirochætes. Nothing special noted in stained preparations.

Spleen.—Slight enlargement only. Malpighian bodies not visible on the surface, but seem to be enlarged when section made. Some congestion present. On staining a smear no vestige of a trypanosome could be found, a somewhat remarkable fact.

Liver.—Slightly congested. Both forms found in smear.

Stomach.—Vessels from smaller curvature engorged. Two areas of congestion shewing early ulceration. But little necrosis present. A smear was made from one of these surfaces but neither trypanosomes nor spirilla were present.

Intestines.—Congestion and ulceration of Peyer's patches. In smears made from these areas a few spirilla were found, similar in appearance to those discovered in the stomach ulcer of Dog 4 (Exp. 9).

Cæcum.—A large punched-out ulcer was present, its surface covered with blood clot. Smears made from the clot and from the ulcerated surface shewed neither trypanosomes nor spirilla.

Large Intestine.—Ulcerated areas present in the transverse and descending colon, These ulcers are more advanced than those in the small intestine. One ulcer measured $\frac{1}{4}$ inch in length and was markedly hæmorrhagic. A smear showed many bacilli, red and white blood corpuscles and a vast number of very thin, lightly staining vibrios and spirilla. Some of the latter were of considerable length possessing from four to six undulations, but they did not resemble the spirilla found in the case of Dog 4 or those present in the smear made from the small intestine.

Fæces.—These were soft, yellow and not offensive.

Mesenteric glands.—These were enlarged and yellow (fatty ?). They were neither congested nor hæmorrhagic.

Lungs.—Markedly anæmic.

Kidneys.—There appeared to be a very early nephritis. Their capsules stripped easily.

Bone marrow.—Red and rather fluid in consistence. Smear showed no parasites.

Brain.—Rather anæmic. A slight increase of the cerebro-spinal fluid which contained trypanosomes. A stained smear of the fluid showed nothing but long forms. Some of the parasites had completely disintegrated, possibly as a result of the spreading out on the slide. Only the centrosomes and free edges of the undulating membranes, the latter prolonged into the flagella, remained.

Some experiments *in vitro* were conducted with the trypanosomes derived from the heart's blood of this monkey, as it was thought that a means of telling whether we were dealing with only one or with two species of parasite, might thus be found. Equal parts of infected blood and sterile citrate solution were placed in sterilised glass tubes and incubated at 37°C., and at a temperature varying between 21·6°C. and 24°C. respectively.

After 24 hours a few somewhat sluggish trypanosomes were demonstrable in the warm tube. In the cold tube lively forms were present.

After 48 hours, living forms were found in both tubes, but those in the cold tube were much more lively and also more numerous. Dividing forms were present in both tubes. In the cold tube, baby trypanosomes were seen separating off from the parent parasites in a manner resembling that figured in Laveran and Mesnil's Treatise, Fig. XX., p. 211. I also noticed appearances suggesting those shown in Fig. II., p. 333 of the Journal of the R.A.M.C. for March, 1905, in connection with the cultivation of the Leishman body. In other words, slender spirilla looking forms could be seen separating from the flagellated parasites. In stained preparations only the long forms were clearly recognisable, though what might have been short forms were seen. It was very difficult to be certain. A general approximation to spirillary form was evident. Both ends of the parasites were pointed and the chromatin was somewhat diffused. Nuclei and centrosomes were apparent, but the staining reactions had altered, and in the specimen kept at 37°C., differential staining had been lost to some extent. The flagella stained indifferently well.

After 70 hours no trypanosomes were found in the tube kept at 37°C. In the cold tube a considerable number of lively forms were present. A few motionless parasites were also noted. The trypanosomes approached still more closely to the spirillar type, being very attenuated. A ruddy staining of the cytoplasm was also noticeable.

After 92 hours the same condition of things was found. There was a still greater approximation to the spirillar type but no true spirilla were found. On staining, no flagella were visible. Curiously altered forms were also present.

After 110 hours it was found that bacterial invasion, always a difficult factor to exclude in Khartoum, had taken place. No living parasites were found, but degenerated forms could be seen.

Exp. 22. Gerbil 12. Weight 15 grams. This was a small dark gerbil, apparently a different species from those hitherto employed. Its blood did not exhibit basophilia.

April 10th. Inoculated with a few drops of blood from Gerbil 10.

April 12th. One long trypanosome found. Very lively. No " tadpole " forms seen as described in T. dimorphum in rats by Dutton and Todd.

April 15th. Blood swarming. Treatment with so-called soluble chrysoidine begun and case therefore considered under treatment (*vide* p. 157).

Exp. 23.—Rat (*Mus decumanus*). Blood free of parasites.

April 12th. Inoculated subcutaneously with ·25 c.c. blood from Gerbil 10 to see if "tadpole" forms developed. The blood was examined daily after April 14th till April 22nd, but no trypanosomes were found. Accordingly Exp. 23a was performed, the rat being again inoculated, this time from Monkey 5.

April 23rd. Rat found dead. Spleen enlarged. Bacterial invasion of the tissues had occurred and no parasites were found in smears made from the heart's blood and various organs.

Exp. 24. Jerboa 6.—This animal was used for an immunisation experiment with blood serum and its case is accordingly considered under treatment (p. 170).

Exp. 25. Monkey 6.—(*Cercopithecus sabæus.*) Weight 1·3 kilos.

April 24th. Inoculated with 1 c.c. blood from Monkey 5.

April 29th. Trypanosomes present in peripheral blood. Nearly all long forms.

May 5th. Both forms present and lively. Twenty to thirty in each field. On staining, the short forms were found to predominate. Many of them were very broad and exhibited chromatin granules, vacuoles and large undulating membranes. Some of the long forms were dividing. This monkey was treated by blood serum injections and its history is therefore considered later (p. 168).

Exp. 26. Gerbil 13.—May 5th. Inoculated from Monkey 5.

May 8th. Both forms present in the blood, the long forms predominating.

May 10th. Animal found dead and decomposing. Bacterial invasion of tissues.

Exp. 27. Gerbil 14.—May 4th. Inoculated from Monkey 5.

May 8th. Both forms present in the blood, the long forms preponderating.

May 21st. Animal chloroformed and blood-agar tubes inoculated from the heart's blood, in which both forms were numerous, and incubated at 22° C. All the tubes became contaminated.

Stomach and intestines examined but no congestion or ulceration found.

Exp. 28. Gerbil 16.—May 11th. Inoculated with a few drops of citrated blood from Monkey 5.

May 16th. Trypanosomes present in the blood but few in number.

May 20th. Many fields devoid of parasites. Two, the greatest number seen in one field.

This gerbil was treated with blood serum and so it is considered fully later (p. 169).

Exp. 29. Gerbil 17.—*May 11th.* Inoculated with a few drops of citrated blood from Monkey 5.

May 16th. Trypanosomes present and numerous.

May 20th. Trypanosomes present and numerous, 6 to 12 per field. A stained film exhibited both forms and, in addition, strange short forms dotted all over with chromatin spots. There were also curious amorphous masses, showing vestiges of their having once been trypanosomes. These apparently were the result of a natural degeneration. Those with the abundance of chromatin possibly exemplified an effort to cope with this destruction, This was thought to be a suitable case for treatment by soluble chrysoidine which was begun on May 21st (*vide* p. 158).

Exp. 30. Monkey 7.—(*Cercopithecus sabæus*). May 15th. Inoculated subcutaneously

with ·25 c.c. blood from Monkey 5. This monkey was untreated and its temperature taken daily (with one exception) during the resulting illness.

Fig. 73.—Temperature Record. Monkey 7.

May 21*st*. Blood examined for the first time. A fair number of trypanosomes found. Very active long forms most in evidence. On staining both forms were well seen.

May 23*rd*. Blood inoculated into Monkey 8.

May 27*th*. No trypanosomes found in a fresh film. Note that this coincided with a fall in the temperature. Blood inoculated into Gerbils 18 and 19.

May 28*th*. Fresh film. After a long search one short form found. It was sluggish, exhibited vacuoles and was apparently somewhat degenerated. Temperature still low.

May 29*th*. Fresh film. Full of trypanosomes, especially long and very active forms. It is worthy of note that the temperature had risen 4° F. since the previous day.

May 30*th*. Blood in much the same condition.

June 10*th*. In the interval the disease had steadily progressed, and the animal had shown the usual symptoms of anæmia, emaciation, dejection, and drowsiness. There was œdema of the left eyelid, corneal opacity, and some blepharitis.

On the morning of June 10th the animal was found dead but not decomposed.

Post-mortem. The only special point noted was a general enlargement of the mesenteric glands.

Peyer's patches were well marked at the lower end of the ileum. No congestion or ulceration found here or in the stomach.

Portions of the lung, liver, spleen, which was slightly enlarged, kidneys and supra-renals were preserved for section preparations.

Exp. 31. Gerbil 18.—May 21st. Inoculated by scratch inoculation from Gerbil 14.

May 27*th*. Examination of the blood having proved negative, the animal was re-inoculated on this date from Monkey 7, the blood of which it will be remembered showed no trypanosomes on this day.

Exp. 31A.—*June* 6*th*. Fresh film found to be swarming with trypanosomes; agglutinating and dividing forms present.

This animal ran a course and died some time after June.

Exp. 32. Monkey 8 (*Cercopithecus sabæus*). Weight, 2 kilos.—May 23rd. Inoculated with ·25 c.c. blood from Monkey 7.

June 7*th*. Animal lively and well. Blood examined for the first time. Both forms present, long ones predominating. There were 6 or 7 per field. Weight 2 kilos. Treatment with soluble chrysoidine begun. Case considered later (p. 158).

Exp. 33. Gerbil 19. Weight, 42 grams.—Red cells showed granular basophilia.

May 27*th*. Inoculated with a few drops citrated blood, in which at the time no trypanosomes were found, from Monkey 7 (page 146).

June 6*th*. Trypanosomes present but not numerous, and only long, lively forms seen.

June 28*th*. Many trypanosomes, mostly long forms.

June 30*th*. In extremis, chloroformed. Weight, 23 grams. *Post-mortem*. Slight conjunctivitis of left eye. Spleen enlarged. No ulceration in the stomach, but non-adherent blood clot present, as well as a bunch of nematodes.

In a smear made from one of the clots degenerated trypanosomes were found (Note by Major Dansey Browning).

The following experiments were partly or wholly performed by Mr. Friedrichs, my laboratory assistant, when I was absent on leave. They were performed merely for the purpose of carrying on the strain, but some notes were kept both by Mr. Friedrichs and by Major Dansey Browning, who from time to time kindly supervised, especially when post-mortems were performed.

Exp. 34. Monkey 10 (*Cercopithecus sabæus*). Weight, 2·3 kilos.—June 15th. Inoculated subcutaneously with ·25 c.c. blood from Monkey 8.

June 21*st*. Blood examined for first time. Trypanosomes, both forms, present, the majority being long forms.

July 14*th*. Animal weak and ailing.

July 16*th*. Found dead. Weight 1·2 kilos.

Post-mortem.—Only points noted were erosion of stomach and congestive patches in the small intestine. Smears from these areas proved negative as regards trypanosomes or spirilla.

Exp. 35. Monkey 12 (*Cercopithecus sabæus*). August 14th. Inoculated from Monkey 10, ·25 c.c. subcutaneously.

August 24*th*. Large infection found.

August 29*th*. Found dead. Weight, 2·2 kilos.

Post-mortem. Apical pneumonia present. Trypanosomes in heart's blood degenerated. An attempt to continue the strain by injection of this blood into Monkey 13 failed, this constituting Exp. 36.

Exp. 37. Gerbil 20. *July* 28*th*. Inoculated with ·25 c.c. from Gerbil 19.

July 7*th*. A few trypanosomes found.

July 29*th*. Very weak.

August 3*rd*. Found dead. Bacterial invasion. No ulceration.

Exp. 38. Gerbil 21. July 29th. Inoculated subcutaneously with ·5 c.c. blood from Gerbil 20.

August 2*nd*. Blood infected.

August 8*th*. Blood swarming with trypanosomes.

August 19*th*. Found dead—decomposed.

Exp. 39. Gerbil 22. *August* 8*th*. Inoculated subcutaneously with ·25 c.c. from Gerbil 21.

August 17*th*. Blood swarming.

August 28*th*. Found dead. Spleen enlarged. No ulceration.

Exp. 40. Gerbil 23. *August* 20*th*. Inoculated subcutaneously from Gerbil 22.

August 22*nd*. Slight infection.

September 13*th*. Dead. Nothing noteworthy found post-mortem.

Exp. 41. Gerbil 24. *September* 5*th*. Inoculated subcutaneously from Gerbil 23.

October 20*th*. Died. No notes.

Exp. 42. Gerbil 25. *September* 14*th*. Inoculated subcutaneously from Gerbil 24.

October 6*th*. Died. No notes.

Exp. 43. Gerbil 26. *September* 21*st*. Inoculated subcutaneously from Gerbil 25. Failure.

Exp. 44. Monkey 14 (*Cercopithecus sabæus*). *August* 17*th*. Inoculated from Gerbil 21.

August 22*nd*. Severe infection.

September 3*rd*. Very weak. Chloroformed.

Post-mortem. Stomach much inflamed and contained three large ulcers. No spirilla found in smears. Curiously altered forms of trypanosome found in a smear from the liver.

Exp. 45. Monkey 15 (*Cercopithecus sabæus*). Weight, 2 kilos. September 3rd. Inoculated subcutaneously with about ·25 c.c. blood from Monkey 14.

September 15*th*. Trypanosomes present.

September 30*th*. None found.

October 5*th*. Two or three present per field.

October 14*th*. Found dead. Weight, 1·2 kilos. Having returned from leave I performed the post-mortem on this animal. The stomach was normal. In both small and large intestines, ulcerated areas were found surrounded by inflammatory induration. Raised red nodules could be seen under the peritoneal lining when the gut was viewed externally.

Smears were made from these ulcers but no spirilla or trypanosomes were found. Portions were kept for section preparations.

Exp. 46. Monkey 16 (*Cercopithecus sabæus*). Weight, 2·8 kilos. October 5th. Inoculated with ·5 c.c. blood from Monkey 15.

October 17*th*. Blood swarming with trypanosomes, both forms being present and easily recognisable, especially on staining.

On this date 1·5 c.c. of this monkey's blood was inoculated into Calf 1, constituting Exp. 47, which has already been considered in the article on cattle trypanosomiasis.

October 19*th*. Treatment with chrysoidine in suspension was begun on this date, and the case is accordingly considered later (p. 159).

Exp. 48. Monkey 19. (*Cercopithecus sabæus*.) Weight 1·7 kilos.

October 22*nd*. Monkey inoculated with heart's blood from Monkey 16.

October 28*th*. A large number of trypanosomes, nearly all long forms, present, three or four per field (oc. 1, oil *imm*. 1/12. Leitz.)

November 9*th*. Both forms. Many vacuolated.

November 15*th*. Animal died in the afternoon. Post-mortem performed at once. Spleen enlarged but firm. No ulceration of stomach or intestines, but slight congestion of mucous membrane of lower part of ileum noted. Otherwise nothing noteworthy. In heart, spleen and liver smears, ordinary, unaltered trypanosomes were seen. In a smear of the bone-marrow, forms like the Leishman body were present, presumably the young forms described by Lingard and already mentioned.

Exp. 49. Monkey 20. (*Cercopithecus sabæus*). Weight, 1·3 kilos.

November 15*th*. Inoculated subcutaneously with heart's blood from monkey 19.

November 20*th*. Examined for the first time and found to be infected. Both forms

present and full of chromatin granules. Some seen undergoing longitudinal division. Animal looks ill and emaciated, but weight was 1·2 kilos. Treatment with chrysoidine begun so considered later (p. 160).

Exp. 50, 51 and 52 have not been concluded at the time of writing and so need not be considered.

I append tables giving details of these inoculation experiments, so that the results obtained can be readily noted (p. 128 *et seq.*).

Having described these, we are in a better position to discuss the identity of the trypanosome or trypanosomes in question. It appears to be always a matter of considerable difficulty to come to a definite decision on such a point, and indeed it may be impossible without the aid of cultivation and immunisation experiments. Koch* has recently raised the question as to whether it will not be possible in certain cases, and especially in the pathogenetic trypanosomes of mammals, to decide the species by a study of the developmental forms in the *Glossina*. The question at issue, it will be remembered, is whether we are dealing with *T. dimorphum* or with an infection by two different species of trypanosomes, one of these being presumably *T. Evansi*. For purposes of comparison I would direct attention to the standard treatise on Trypanosomiasis by Laveran and Mesnil, which deals fully both with *T. dimorphum* and *T. Evansi*; to the work of Dutton and Todd, on the former parasite, found in horses in Senegambia, and to the very full report of Musgrave and Clegg, which refers especially to Surra in the Philippine Islands.

Resemblances to T. dimorphum

Dealing first with the morphological aspects of *T. dimorphum* as described by Dutton and Todd, who discovered it, I think it will be apparent to anyone who compares their photomicrographs of the horse trypanosome of the Gambia with those of the mule trypanosomes of the Sudan, Fig. 69, that they are extremely alike. This applies at least to their Figs. 2 and 3, on Plate 1. There, long forms exactly similar to those shown in Fig. 69 appear, while their so-called "stumpy" parasites correspond closely to what I have described as short forms.

Again comparing their long forms in the coloured plate with those in my stained specimen, I find a great similarity in structure.

On reading the descriptions of their long and "stumpy" forms, one finds their account of the former agrees with that I have given of the long forms in mules with one possible exception.

They state that these forms are most numerous in the blood of an infected animal a few days before its death.

In my untreated cases they occurred early in the infection, persisted throughout the disease and were not specially numerous ante-mortem.

Taking next their "stumpy" forms. These appear to answer fairly closely to my short forms—at least, as seen in experimental animals. In the original mule's blood I never found them so broad as they describe. They note that the stumpy forms survive for a longer time in fresh preparations than the long forms. I have found this true of my short forms so far as cover-glass preparations go. Sometimes it is very difficult to say if a trypanosome is really a short form or a long form which has become much broader than usual prior to division, and in which the flagellum has not stained well or is not well developed. This leads to confusion, and possibly may account in some measure for the intermediate

* Sitzungber d. Kaiser pr. Akad. d. Wiss., Berlin, Nov. 23rd, 1905, p. 958-962.

forms mentioned by Dutton and Todd. I may also have mistaken altered and dividing long forms for short forms in process of division. Dutton and Todd state that they never witnessed their stumpy forms undergoing fission.*

At the same time I have certainly seen in crowded slides what I should call intermediate forms, another point of resemblance between their *T. dimorphum* and the trypanosomes of mules. I have, however, never seen the faintly staining hyaline form they describe, nor have I met with the "tadpole forms" they describe in rats and mice. This may be because I have not employed the same kind of animals as they did. However, in the case of Monkey No. 4 when undergoing the serum treatment, I saw small forms which certainly answered very closely to their description of the "tadpole" forms. (Plate XIV., Fig. *c*.) Indeed, their "tadpole" form is not at all unlike the *T. nanum* of cattle, save that it has a longer flagellum. Occasionally, and more especially in blood smears from internal organs, I have seen the round forms figured in their coloured plate, and which may be altered female trypanosomes, macrogametes.

On the whole then, from a morphological standpoint, the mule trypanosomes approximate very closely to the description of *T. dimorphum* given by Dutton and Todd.

Let us see how they fare when compared with the account given by Laveran and Mesnil. These observers did not see a long free flagellum in the long forms of *T. dimorphum*. I have already quoted Professor Laveran on this point. They never observed the "tadpole" forms, nor the pale hyaline variety. The French savants state that the undulating membrane is never very well developed, and that in the short forms it is united very closely to the body, properly so-called. In the trypanosome of mules, as found in the blood of experimental animals, the undulating membrane is often very well marked, and, as has been pointed out, is frequently "bunched" on the body of a short form in a way which reminds one of what is found in the trypanosomes of fish and reptiles, though it is never extremely prominent save in involution forms.

The French authorities do not recognise the intermediate forms and state that granulations are rare.

There is, however, nothing in their observations which would lead one to declare that the trypanosome of mules is not *T. dimorphum*. It is well known that in different animals the same trypanosome may present very different aspects, and if some variation can be admitted as regards flagella it can also be admitted for the undulating membrane and the presence of chromatin granules. Further, at different stages of the disease different appearances are exhibited, and it is only recently that attention has been directed to the existence of asexual and sexual forms.

Comparison with T. Evansi

As regards the parasites of Surra, the long forms in mules certainly resemble *T. Evansi*. It would seem that the latter is more mobile, frequently traversing the field of the microscope, but little can be based on such an observation.

If the long form be *T. Evansi*, what is the short form? One naturally thinks of *T. nanum*, the cattle trypanosome found in the same regions, but from a morphological standpoint I do not think the two are identical. The question could only be satisfactorily settled by inoculation of the mule trypanosomes into cattle, and so far I have neither had

* It is possible in both cases that these short forms really represent female trypanosomes, while two forms of long parasite may exist, an asexual form which undergoes longitudinal division and a male sexual form, a microgamete, represented by slender trypanosomes with a hyaline cytoplasm and very long flagella.

the means nor facilities for conducting this work on a large scale. The single experiment performed (*vide* p. 122) goes to show that the short form is not *T. nanum*.

On the whole, considering the matter from a morphological standpoint, I am strongly inclined to think the mule trypanosome is *T. dimorphum*. Nor when we turn to compare the result of experimental inoculation is there anything forcible to be urged against such a view. I have not been able to carry out so admirable a series of experiments as that conducted by Drs. Dutton and Todd,* but so far as they go my results approximate very closely to theirs. True, they did not note any affection of the eyes in dogs, but no doubt this is a variable symptom. Laveran and Mesnil † state that it only occurs occasionally in the case of *T. Evansi* in dogs. It seems more constant for *T. Brucei* than for any other variety. The Liverpool observers found gland enlargement constant in rats; I have not observed it either in gerbils or jerboas, but I have now worked with rats proper to a small extent and have found this to be the case.

In their solitary rabbit the conjunctiva and eyelids remained normal. In one of my cases a condition exactly similar to that found by Musgrave and Clegg,‡ by Sivori and Lecler and by other investigators, developed.

Dutton and Todd employed monkeys of different species to those with which I worked. In one of them, a baboon, they found the stomach congested and containing altered blood and mucus.

They seem to have obtained very similar results in goats to what I found in the solitary goat I employed.

It is scarcely worth while to pursue the argument. Granting that *T. dimorphum* is a distinct entity, I think the trypanosome of mules in the Sudan approaches it more closely than any other trypanosome of which I have records. The tendency is to follow Koch and pay less attention to differences in species and more to the presence or absence of pathogenicity. I have attempted cultivation experiments, but so far without any success. Either nothing developed in the blood-agar tubes or contamination occurred. Had I known that *defibrinated* blood is not essential in preparing the culture media, this accident might have been avoided. As regards the trypanosomes found in blood smears from a donkey in the Bahr-El-Ghazal, I may note that the specimens were old and stained badly. As far as one could tell, the parasites rather resembled *T. Brucei*. Only one form appeared to be present. I have not yet been able to work out the small trypanosome I have found in mules, but I am not at all sure that it is not *T. nanum*. I know of two instances in which recovery apparently occurred. It will, perhaps, be of greater interest to consider the special post-mortem lesion to which I wish to call attention, namely, the affection of the gastric and, to a less extent, the intestinal mucous membrane.

Gastric and intestinal lesions and their possible significance

References to such a condition are not wanting in the literature. Dutton and Todd's note in reference to a baboon has been mentioned, Musgrave and Clegg record the presence of intestinal ulcers and ulcers in the cœca of animals dead of Surra in the Philippines. As a rule, however, attention does not seem to have been paid to the condition of the alimentary tract, and so far as I know, when lesions have been noted, smears have not been taken nor any further examination performed. Greig's recent observations on human trypanosomiasis have been mentioned.

* First Report of the Trypanosomiasis Expedition to Senegambia 1902, Liverpool 1903.

† Trypanosomes et Trypanosomiasis. Paris, 1904.

‡ Trypanosoma and Trypanosomiasis with special reference to Surra in the Philippine Islands, No. 5 Publication. Bureau, Govt. Labs. Manila, 1903.

My number of post-mortems in the case of experimental animals now totals forty-nine, and in sixteen of these gastric or intestinal ulceration or marked congestion was present. In one case (Exp. 8) there was severe ulceration of the cœcum and lower end of the ileum.

I do not think that this can be a mere coincidence. A similar condition was found in the stomach of a Shilluk ox infected with *T. nanum*, and I am inclined to think that such lesions will be found to be common in trypanosomiasis.

As to their significance, one scarcely likes to hazard an opinion, but the thought that naturally arises is whether this condition may not indicate an effort on the part of the parasite to leave its host. Biting flies are regarded as the usual media by which trypanosomes leave the body of an infected animal, though Rogers * has shown that the ordinary house fly will serve the purpose in the case of open wounds, and fleas and other blood-sucking insects are said to be effective as agents of transmission. In this connection I may state that I have found trypanosomes in blood expressed from a mite (*Dermanyssus* sp.? probably *gallinæ*) twenty-six hours after it had fed on an infected rat. Many of the parasites were lively, but some were dead. A fine rosette form was also seen. On staining, unchanged parasites were seen together with broken-down forms showing only centrosomes, free edges of their undulating membranes and flagella. Nothing to suggest a developmental stage was seen nor were dividing forms noticed.

At the same time the life-history of the trypanosomes of mammals is still obscure, and it is only recently that attention has been directed to the multiplication of *T. gambiense* in the stomach of *G. palpalis*,† while it is only since the above was written that Koch's remarkable observations,‡ carried out in German East Africa have been made public, which, if confirmed, will mark a great advance in our knowledge.§ Is it not possible, however, that if flies are not available, the parasite may escape from the body in some different manner? If so, may the gastric and intestinal lesions not be evidence of such exit? The condition found in Cachexial Fever due to the Leishman bodies‖ will at once occur to any interested in this important subject. At the same time we are immediately met with the argument that no one has ever found trypanosomes in the stools of infected animals, nor have such stools been definitely shown to be capable on injection of reproducing the disease; Lingard, it is true, states the contrary, but he is generally regarded to have been mistaken, and Musgrave and Clegg, who paid special attention to this point, deny that the stools can convey infection. Rogers also refutes Lingard's contention. Moreover, ulcerated conditions of the alimentary tracts in the lower animals is, I believe, far from uncommon in hot countries.

In the face of all the evidence which has been accumulated, and in the absence of any experiments with the stools of inoculated animals, one is not justified in putting forward any theory. At the same time the occurrence of spirilla in the gastric lesions may or may not be regarded as a fact worthy of note and there certainly seems to be a general impression that trypanosomes and spirilla will be found to be very closely related, if they are not indeed merely different stages in the life of one parasite. This was first suggested

The occurrence of Spirilla

* Brit. Med. Journ., London, Nov. 26th, 1904, p. 1,454.

† Reports of the Sleeping Sickness Commission of the Royal Society, No. VI., part 14.

‡ Deutsch. Med. Wochenschrift, Leipzig, Nov. 23rd, 1905.

§ *See* however the recent paper by Novy (Jour. Inf. Diseases, 18th May, 1906), which discredits this work as do the results obtained by Minchin.

‖ Christophers' Scientific Memoirs. Med. and Sanit. Depart., India, Nos. 8 and 11.

by Schaudinn's work* on the developmental cycle of the *Hæmamœba* or *Spirochæte Ziemanni* of the Stone Owl in *Culex pipiens*, but it is worth noting that Novy and McNeal† have not confirmed his observations, while quite recently Ross‡ has suggested a possible source of fallacy in Schaudinn's allied researches.§ Now, I have no wish to commit myself to any theory. It does not seem likely that a trypanosome would change into a spirillum in the blood of the same host, and I have seen nothing which would lead me to suspect that it does, but Theiler‖ has recorded both forms of parasite as occurring in the blood of cattle suffering from ordinary red-water and Rhodesian red-water fever. Petrie has** also described a Spiroehæte in the blood of a Martin which at the same time harboured a trypanosome in its bone-marrow. Further, the spirilla, which I describe, are shortish forms, and have not the typical pointed ends of, say, *Spirochæte Obermeieri*. For all that they are undoubted spirilla, and I have found them on several occasions in gastric lesions of animals dead of trypanosomiasis. I think it is an interesting observation. At present it is nothing more, but it seems worth while following up the matter. With the highest powers at my disposal, it looked as though these spirilla were possessed of something like undulating membranes. Further observations lead me to doubt this. I believe these organisms to be of a bacterial nature or at least true spirilla as distinct from protozoa.

I have never found such spirilla present in the stomach or intestines of animals uninfected with trypanosomiasis. Another question arises, What is the nature of these small "ruddy" forms (Plate XIV., Fig. *f*) found in the gastric lesions present in Gerbil 8 (Exp. 16) and Jerboa 3 (Exp. 19)? I confess I am unable to answer the query. They are possibly related to the young resistant forms described by Lingard, and which closely resemble the Leishman-Donovan bodies found in Cachexial Fever.

IV. Prophylaxis and Treatment

Prophylaxis

As regards the former little need be said, as in a region like the Southern Sudan but little can be done of any practical value, and the country is not yet sufficiently developed to make the presence of the disease severely felt. At present the big game is probably of greater value than the native flocks and herds. Steps have been taken to limit the trade with Shilluk cattle, though apparently *T. nanum* has never been introduced into the Northern Sudan. As stated, Captain Head has recently examined the blood of hundreds of cattle in the Berber district and elsewhere, in connection with the rinderpest outbreak, and he has not come across a single case of trypanosomiasis. Mention has been made of the fact that the animals in the rear of a caravan are likely to escape being bitten by Tsetse flies.

Attempts at therapeutic measures

Treatment has so far been conducted on two lines. Having noted†† that the best results in the treatment of trypanosomiasis had been obtained by the use of certain anilin dye-stuffs, namely, trypan red and malachite green,‡‡ whether combined or not with arsenic, it

* Generations und Wirtwechsel bei Trypanosome und Spirochæte. Arb. ausdem Kaiser. Gesundheit., Bond XX., Heft 3, 1904. Translation in Brit. Med. Journ., London, Feb. 25th, 1905, p. 442.

† Journ. Infect. Dis., Chicago, March, 1905.

‡ Journ. Hyg., Cambridge, Jan. 1906.

§ *See* also the recent work of Novy and others (Journ. Inf. Diseases, 18th May, 1906), and for a review of the whole subject the articles on Hæmoflagellates in the Quart. Journ. of Microscopic Science, April and June, 1906.

‖ Fortschritte der Veterinärhygiene, 1903, Heft IV.

** Journ. Hyg., Cambridge, 1905, Vol. V., p. 191.

†† Laveran. Compt. Rend. de l'Acad. des Sciences, Paris, Vol. CXXXIX., p. 19.

‡‡ Brit. Med. Journ., London, Dec. 17th, 1904, p. 1645.

occurred to me that it might be well to test the therapeutic action of another anilin colour, *i.e.*, chrysoidine, the hydrochloride of di-amido-azo-benzene (C_{12} H_{12} N_4 HCl.). Though I had no proof of its value yet I had obtained somewhat suggestive results with it in conditions other than trypanosomiasis. Thus, some years ago, I found that it was extremely lethal to fish even in very dilute solutions. Further, of all the dyes used in experimenting it seemed to have the greatest penetrating power, appeared to pass very readily into the blood stream, and undoubtedly possessed a marked affinity for the central nervous system, staining the brain and spinal cord a brilliant yellow colour. Although so toxic to fish, comparatively large doses could be given with impunity to rabbits. Weyl,* who experimented with dogs, regards chrysoidine as non-poisonous, but states that it causes a notable reduction in body-weight and slight albuminuria. Its toxic action on fish probably depends on its being an azo compound, but its effects were very similar to those of methylene blue. It proved, however, more poisonous and more speedy in action. As methylene blue is known to benefit cases of bilharzia disease and to exercise a lethal effect on the ciliated embryo of *Schistosomum hæmatobium*, I first of all tested chrysoidine on this myracidium and found that in a strength of 1 in 20,000 the dye killed the embryo practically instantaneously, while a solution of 1 in 200,000 proved lethal in 17 minutes. Remembering that methylene blue has been exhibited with some benefit in malaria, it seemed to me that possibly chrysoidine might be found beneficial in cases harbouring protozoal blood parasites. Further, its affinity for the nervous system seemed to point to a possible value in a disease like trypanosomiasis where the late and really lethal effects are produced by an invasion of the cerebro-spinal system—at least, such is the view at present held as regards human trypanosomiasis. I admit such reasoning is none too conclusive, or even hopeful, but many drugs have been tried in many diseases with still less reason and often merely empirically.

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nploying
rysoidine

Dr. Sheffield Neave, impressed by the experiments on bilharzia embryos and acting wholly on his own initiative, took some of the dye up the White Nile with him and had an opportunity of testing the drug on a case of human trypanosomiasis, the history of which will be found fully detailed later. Meanwhile, I proceeded to carry out some tests in vitro, employing Merck's product, a black or dark purple, shining crystalline powder which is somewhat insoluble, ·1 gram in 10 c.c. distilled water constituting a saturated solution which is of an intense orange red colour.

Such a solution added to trypanosome infected blood in a proportion of 1 to 500, killed all the trypanosomes present practically instantaneously. They were stained slightly by the yellow dye. On staining such dead trypanosomes by the Romanowsky method they were found to take the colour badly, and to have swollen posterior ends. They looked as if they had shrunk into themselves.

Experiments in
itro

In a strength of 1 to 6,000 some trypanosomes were observed to die in five minutes. Others, though retaining their motility, became rounded, and these also died after forty-five minutes. After four hours only one living trypanosome could be found. Though lively it had changed in shape, and looked like an involution form. Although weaker mixtures, even 1 in 30,000, killed some of the parasites, many were found to survive. In all cases controls were performed, and the blood was mixed with sterile citrate solution. No agglutination was observed. The dye was not so lethal as I had hoped, but I resolved to give it a trial. The following are the records of cases treated with it.

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* The Sanitary Relation of the Coal Tar Colours (Leffman), p. 126.

Exp. 2. Dog 2.—*February* 12*th*. Weight 9 kilos. About 30 trypanosomes per field, 1 c.c. sat. sol. Chrysoidine (·1 gram in 10 c.c. aq. dest.) injected subcutaneously.

Records of cases

February 13*th*. 2 c.c.

February 14*th*. 2·5 c.c. Animal livelier.

February 18*th*. 2·5 c.c.

February 16*th*. 2·5 c.c. Blood examined. Only two trypanosomes per field seen at the most. Many fields barren. The parasites seemed to be rather sluggish, but no special change was noted in them.

February 17*th*. 2·5 c.c. Animal ill and very weak.

February 18*th*. 2·5 c.c. Blood examined, and found to be simply swarming with trypanosomes which had greatly altered in appearance. Nearly all of them had become more granular, and exhibited swollen posterior ends. In addition, curious involution forms were present. One apparently unaltered form showed extreme activity, jerking and twisting very violently, and having also a considerable movement of translation. Many forms were sluggish, and a number became motionless forty-five minutes after the slide was prepared, Agglutination on a small scale was also seen to take place about this time. A certain number, all long thin forms, remained active and lively. Further, dividing forms were present, and many were seen united by their posterior ends.

On staining, the above points were emphasized and vacuoles were found to be present, the vacuoloid area close to the centrosome being very well marked in the short forms.

February 19*th*. Dog distinctly better, though still very weak.

Weight, 6·25 kilos.

3·5 c.c. given.

Blood much as above, but no agglutination forms seen.

Long forms very active.

The animal did not take food well in the afternoon, and appeared to be thirsty.

February 20*th*. Found dead, stiff and cold in the morning.

The post-mortem has been mentioned (p. 126). Bacterial invasion had occurred, and no trypanosomes were found in any of the smears.

Exp. 6. Dog 3. *February* 27*th*. ·5 c.c. sat. sol. given intravenously.

February 28*th*. 1 c.c. sat. sol. given intravenously.

March 1*st*. 2 c.c. sat. sol. given intravenously.

March 2*nd*. 2·5 c.c. intravenously.

No change in the dog's condition had been apparent. Owing to great press of work the examination of the blood was put off from day to day, and the dog was found dying on March 3rd. A post-mortem was performed immediately after death, and no trypanosomes were found in any of the smears made from heart's blood, liver, spleen and thymus gland, which was enlarged. The urine was of a very deep yellow colour, and though I have no proof of it, I am not at all certain but that the chrysoidine was the immediate cause of death in this case. There was slight nephritis. I have, however, given a control dog considerable doses, about 2 c.c. daily, intravenously, for a prolonged period without any ill effects resulting.

Exp. 8. Monkey 2. Weight, 2·5 kilos. *February* 21*st*. Blood full of trypanosomes, about 20 per field—3 c.c. sat. sol. (·1 gram in 10 c.c. aq. dest.) given subcutaneously.

February 22*nd*. Animal seemed livelier. Only about six parasites per field. 3 c.c. given.

February 23rd. 3 c.c. given. Six to twelve per field.

February 24th. 3·5 c.c. given.

February 25th. 6 c.c. given.

February 26th. 6 c.c. given. No apparent change.

February 27th. 6 c.c. given. Weight 2·9 kilos.

February 28th. 6 c.c. given. Blood examined, no trypanosomes found after a prolonged search.

March 1st. 6 c.c. given. Blood examined, a few trypanosomes found.

March 2nd. 6 c.c. given, as many as four trypanosomes seen in some fields. Several motionless and disintegrating forms visible.

March 3rd. 9 c.c. given. No change.

March 4th. 9 c.c. given. No change. Weight, 2·5 kilos.

March 5th. 9 c.c. given. Not more than two trypanosomes seen per field. Both kinds well shown. Many were vacuolated, vacuoles being specially numerous in the short, blunt forms. Plate XIV.; Fig. *d.* The animal appeared to be less sleepy, and seemed to be suffering from itchiness as it kept tugging at its coat.

March 6th. Increase in number of parasites. Urine a marked yellow.

March 7th. Blood swarming with parasites. 12 c.c. given. Weight, 1 kilo.

March 8th. Monkey in extremis and chloroformed.

Although the trypanosomes altered somewhat in appearance and for a day disappeared from the peripheral blood, I do not think the treatment in any way influenced the course of the disease.

There was no staining of the brain, spinal-cord or nerve trunks in this case. It does, however, occur when larger doses are given (*vide infra*).

Exp. 13. Dog 5. *March 23rd.* Blood contained about 12 trypanosomes per field. Nearly all were long forms, and they were very active. 10 minims (*i.e.*, ·59 c.c.) sat. sol. chrysoidine injected intravenously.

Same dose employed on *March 24th*, *25th* and *26th*, without any effect. Blood swarming with parasites.

March 27th. 20 m. given. Blood remarkable.

Trypanosomes agglutinating, many motionless. Remainder sluggish. Within four hours they were all dead and most had broken down into debris.

March 28th. 20 m. given. Hardly any trypanosomes seen in the fresh blood. After a long search three sluggish forms found in the whole cover slip preparation. A larger number evident in the stained film, but very few compared with what was found previously.

March 29th. 30 m. given. A slight increase in the number of trypanosomes. The parasites were sluggish and lacked definition of outline. Several motionless forms seen, and curious "shadow" forms. Plate XIV.; Fig. *c.*

Animal very thin and weak.

March 30th and *31st.* 30 m. given each day. No change.

April 1st. Blood in much the same condition. A few agglutinating forms. 20 m. given. In the afternoon the dog was found lying on its side with neck outstretched and eyes fixed. The conjunctival reflex was present. The limbs were rigid, and every now and then the dog kicked, as it were, with its hind legs. The limbs would remain passive and rigid and then be thrown into convulsive movements. Respirations were rapid and noisy. As it was late in the day when this seizure was developed the animal was chloroformed, kept in the ice chest over-night, and the autopsy performed the following morning. The results of

the examination have already been described (p. 139). Is it possible that a rapid destruction of the parasites occurred, resulting in a liberation of the toxines, the stress of which fell upon the central nervous system ?

Exp. 20. Gerbil 10. Weight 34 grams. *April 8th.* Found infected. Mostly long forms.

April 9th. 10 m. sat. sol. chrysoidine subcutaneously.

April 10th. Fresh and stained films examined. No change noted. 10 m. given.

April 11th. No change noted. 15 m. given.

April 12th. No increase in number. Very few long forms present. No marked change in appearance. 20 m. given.

April 13th. Marked change. Many involution forms. In the fresh blood few forms were seen and these were very sluggish, not moving about at all, but all stationary, and presenting what may be called "rippling" movements. Vacuolation and change in shape noted on staining. Animal well. 20 m. given.

April 14th. Only two trypanosomes found per cover-slip preparation. These were long but sluggish forms. On staining, a decrease in number was evident. 20 m. given.

April 15th. An evident increase. Trypanosomes more lively. Some involution forms. 20 m. given.

April 16th. Animal well and lively, 20 m. given.

April 18th. Blood swarming. Forms with broad posterior ends and huge undulating membranes —probably prior to division—found. Animal fairly well.

April 19th. Found dead—decomposing.

Post-mortem. Bacterial invasion. Spleen enlarged. It may be mentioned here that these chrysoidine solutions were centrifuged before use.

Exp. 22. Gerbil 12. This animal was treated with the so-called soluble chrysoidine—chrysoidine extra of the Anilin Manufacturing Company of Berlin, being the same preparation as employed by Weyl in his pharmacological experiments.

April 15th. 10 m. of a saturated solution of soluble chrysoidine given on this the 5th day after inoculation. Blood swarming.

April 16th. Blood full of trypanosomes, mostly broad, sluggish forms. On staining, forms in process of division and some with huge undulating membranes seen. 15 m. given.

April 17th. Motionless forms present in the blood. Also curious involution types. Many active parasites seen. 20 m. given.

April 18th. No change. 20 m. given.

April 19th. A very interesting blood. In fresh films many motionless forms seen On staining, normal looking trypanosomes were apparent together with many curious dead forms; some spherical, some with very blunt posterior ends, and many vacuolated. Leucocytosis was present, but no phagocytosis was observed. 20 m. given.

April 20th. Much as on the 19th, but the peculiar forms still more abundant. The animal died in the afternoon.

Post-mortem. The tissues generally, and specially the brain, spinal-cord and nerve trunks were stained yellow. The spleen was slightly enlarged. No œdema or hypertrophied glands.

Smears. The heart's blood contained the remarkable forms above mentioned. These were also present in the liver smear together with forms very like Leishman-Donovan bodies and apparently the young resistant types described by Lingard. The main difference from

Leishman-Donovan bodies consisted in the micronucleus or blepharoplast being a round dot and not a small rod, like a stout bacillus, such as is found in the human parasite.

Exp. 29. Gerbil 17.—*May* 20*th*. Blood remarkable in that while it contained both forms as usual there was a large number of curious short forms possessing numerous dots of chromatin scattered throughout their cytoplasm, spherical, vacuolated and granular types were also present. Some were so altered that they bore very little resemblance to trypanosomes. 1 c.c. of a saturated solution of soluble chrysoidine was given subcutaneously.

May 21*st*. Animal well. Blood swarming with both forms of trypanosome. The parasites were very active. 1 c.c. given as above.

May 22*nd*. Fresh blood swarming. Many curiously broad forms with large undulating membranes. No motionless parasites seen. The trypanosomes did not stain well. 1 c.c. given as above. The animal, which seemed quite well and lively, unfortunately died during the night, and was found much decomposed.

The post-mortem examination revealed an enlarged spleen and a brain and spinal-cord stained a brilliant yellow. Smears were negative as regards the presence of trypanosomes.

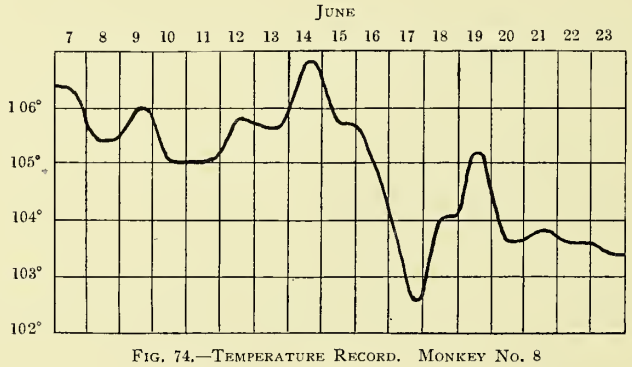


Fig. 74.—Temperature Record. Monkey No. 8

Exp. 32. Monkey 8. Weight 2 kilos.—*June* 7*th*. Six or seven trypanosomes per field. 1 c.c. soluble chrysoidin by intramuscular injection.

June 8*th*. Many lively trypanosomes, both long and short. Some vacuolated and some exhibiting large undulating membranes. Animal had diarrhœa. A smear of the fæces showed spirilla somewhat resembling those found in lesions of the stomach and small intestine. 1 c.c. given as above.

May 9*th*. Animal lively, no change seen in fresh blood film. In the stained preparation many long forms in process of division were seen. Many of the short forms were broad with large undulating membranes and contained numerous vacuoles and chromatin granules. 1 c.c. given as above.

June 10*th*. Animal lively. Blood in much the same condition. 3 c.c. given. Urine markedly yellow.

June 11*th*. No changes noted. 5 c.c. given.

June 12*th*. Many dividing forms in the blood. Appetite excellent. Urine and fæces both stained. 5 c.c. given.

June 13*th*. Monkey lively. Degenerating and dead forms present. Apparently only the short forms affected. Some strangely altered in shape. 10 c.c. given. Blood examined two hours after this inoculation but no further change observed.

June 14*th*. In much the same condition. 10 c.c. given. This dose was continued

every day thereafter till June 19th. About June 18th the animal began to show distinct signs of weakness. Emaciation set in but there was very little somnolence. Towards the end the trypanosomes increased in number in the peripheral blood. The monkey was found dead on the morning of June 24th, and slight decomposition had occurred. The temperature record during treatment is shown. Fig. 74.

Post-mortem. The only marked change consisted in an ulcerated area at the lower end of the ileum. It was not hæmorrhagic in nature but there was a good deal of congestion present. A smear was made but unfortunately was mislaid, and I have no notes of the condition found. There was no gastric ulceration. The spleen was not enlarged nor was the liver increased in size or congested. A smear was made of the semi-fluid contents of the large gut but it shared the fate of the intestinal smear.

As from results obtained with *T. Gambiense* by Dr. Neave it seemed possible that a better result might be obtained by injecting the dye as a suspension and in larger quantities than hitherto given,

Exp. 46. Monkey 16 (Weight 3 kilos.) was conducted, beginning on the fifteenth day after inoculation.

October 17th. Blood full of trypanosomes. Both forms present.

October 19th. 2 grains of Merck's chrysoidin given as a suspension by intramuscular injection.

October 20th. Urine markedly yellow. Colour test with HCl. positive. Blood swarming. Short forms showed vacuoles and many chromatin granules. 2 grains given.

October 21st. Monkey very weak. Some rosettes of the short forms seen, and certain of the long forms appeared to be degenerated. 2 grains (*i.e.* ·13 gram) as above.

October 22nd. Monkey very ill, the head held low and a general aspect of extreme depression presented. 2 grains given in the morning but the monkey died in the afternoon, being the 18th day after inoculation.

Post-mortem.—Spleen enlarged and very much congested. Smears made from this organ showed a very remarkable state of affairs, in that many of the trypanosomes had almost completely broken down, nothing being left but the centrosomes, the free edges of the undulating membranes and the flagella. Curious spherical and faintly stained "shadow" forms were also present. So were vacuolated forms as well as apparently unaltered trypanosomes. Sections were prepared for further study.

The liver was enlarged and congested. There was no gastric or intestinal ulceration. A smear from a congested area of gastric mucous membrane proved negative as regards the presence of parasites. The brain and spinal-cord were slightly yellow. A smear of the cerebro-spinal fluid exhibited the presence of unaltered trypanosomes in considerable numbers. No streptococci were seen.

In the bone-marrow some altered trypanosomes were present. Most of these were the faintly staining and probably moribund "shadow" forms. They were not numerous. There is little doubt but that the administration of chrysoidine hastened death in this case, though whether the dye proved fatal by reason of its own toxic action on the tissues, or on account of the great destruction of parasites, I cannot as yet say. No convulsions were seen, and it will be noted that the trypanosomes found in the cerebro-spinal fluid were of normal aspect. This case served to confirm my view that the drug was of no value in infection with *T. dimorphum*, but a last trial was made in the following experiment.

Exp. 49. Monkey 20 (weight 1·2 kilos) which had been inoculated on November 15th.

November 29th. Both forms present and numerous, some undergoing longitudinal division. Monkey ill and emaciated. Given 2 grains Merck's chrysoidin subcutaneously in suspension.

November 30th. Found in a curious, giddy, stuporose condition. Pupils slightly contracted. The animal kept swaying to and fro and the head was held low. Though dull and dazed it could be roused to attention.

Blood examined. Some dead and "shadow" forms found. Dividing forms present. No marked disintegration. 3 grains given as above. Shortly after their administration the animal collapsed and lay upon its side in the cage. After the lapse of an hour as it was apparently in extremis, chloroform was administered.

Post-mortem.—Liver and spleen enlarged and congested. The latter organ had an old puckered cicatrix running across its anterior surface. Some congestive patches were present in the stomach, probably of a physiological nature.

Intestines healthy. A small deep purple gland was found in the mesentery. Brain, spinal-cord and nerve trunks were all stained an intense yellow colour. The cerebro-spinal fluid was blood-stained but not yellow.

Microscopic examination. — Cerebro-spinal fluid. A fresh preparation showed living and dead forms of trypanosome. The former were sluggish, or speedily became so. On staining, dead, altered, and degenerated forms were seen, as well as an unaltered trypanosomes.

Gland smear.— As above, and young forms as described by Lingard,* resembling Leishman-Donovan bodies.

Brain smear.—Some altered and many unaltered forms.

Liver smear.—Mostly unchanged forms. Some dead and altered forms.

Spleen smear.—Not so many trypanosomes as in the liver smear, but a very large proportion of the curious spherical and "shadow" forms showing segmented nuclei, Centrosomes well marked.

Heart's blood.—Most of the trypanosomes stained well, and were unaltered. A few changed forms were present. Portions of the liver, spleen and brain were kept for section work.

hrysoidine a ilure in the ypano- omiasis of ules

It will be seen that in the case of what is probably *T. dimorphum*, a trypanosome admittedly very resistant to any of the known modes of treatment, chrysoidine has proved a failure. In no instance has it prolonged life, while on several occasions, when given in doses large enough to profoundly affect the parasites, death of the host has resulted. Two forms have been tested, nine cases in all have been treated, the dye has been given in varying doses, both in solution and in suspension, and though interesting effects have been observed, it cannot be said that these have proved of a beneficial nature. Dr. Chauvin of Mauritius writes me to say that he has tried chrysoidine there in horses suffering from Surra, but with no success whatever. Whether a combination of the dye with an arsenical preparation, such as has been employed along with trypan red, would yield better results, I cannot say. Time has not admitted of a trial of this nature.

As already mentioned, Dr. Neave†‡ had an opportunity of testing chrysoidine on a case of human trypanosomiasis from Uganda, in the case of the boy Wariga mentioned in his report.

* Indian Med. Gazette, Calcutta, 1905, Sept. Vol. xl., pp. 333 *et seq.* and 381.

† Lancet, London, June 13th, 1905, p. 1,645.

‡ For Dr. Neave's account of the case, see p. 185.

I have continued his work, and extended the observations to monkeys. Dr. Neave's report was so encouraging that it seemed justifiable to go on with the treatment.

Case of Human Trypanosomiasis

April 29th. Dr. Neave performed gland puncture on the boy who, owing to the exigencies of travel, had not had a dose for ten days. On examining the gland juice I found two somewhat altered trypanosomes answering in morphological detail to *T. gambiense*. The superficial cervical glands along the anterior margin of the sterno-mastoid were enlarged, though not markedly so, and were somewhat shotty to the touch. The boy was fairly well nourished, but had rather a sleepy and stupid aspect. An arrangement was made with Captain, now Major, Dansey Browning, whereby the boy was to be kept at the Military Hospital, and to receive $\frac{1}{4}$ grain chrysoidine every second day by intramuscular injection.

Case of human trypanosomiasis

On *May 5th.* Captain Browning reported that the boy's speech seemed affected. He was seen on May 6th and examined. He certainly seemed to have some difficulty in enunciation, his speech being almost of a "staccato" nature, but we found afterwards that this was merely a natural defect and due in some measure to his not understanding any Arabic, in which language he has since made considerable progress. He seemed dull and heavy, but no tremors were noticed. Neither peripheral blood nor gland juice showed any trypanosomes. His case was carefully gone into, but it was difficult to take as he was ignorant of any language with which we were acquainted, and we were ignorant of his tongue. We were unable to detect any abnormality in the nervous system. Indeed, the only sign of disease about him was the cervical glandular enlargement.

He was well clothed and well fed, and his dose was increased to $\frac{1}{2}$ grain daily. It produced no local ill-effects.

May 25th. Gland puncture performed. No trypanosomes found. Boy fat and well. Has been making himself useful about the hospital. Glandular enlargement as before.

June 9th. Very well. Blood and gland juice negative. An attempt to make a full blood count failed, owing to the atmospheric conditions prevailing.

A differential leucocyte count was conducted with the following result:—

Counted 500

	Eosinophiles	Polymorphonuclears	Mononuclears	Lymphocytes	Transitional	Basophiles
Number	133	84	101	175	6	1
Percentage	26·6	16·8	20·2	35	1·2	·2

The high percentage of eosinophiles is noteworthy. It was probably due to intestinal parasites.* On this day about 1 c.c. of venous blood was taken, citrated, and inoculated subcutaneously into Monkey 9 (*vide infra*).

June 13th. Blood count made.

R.B.C. 3,900,000.

Leucocytes 6,000.

Hb. 70 per cent.

A photograph of the patient taken on this date is shown (Fig. 75). Gland juice

* This proved to be the case, as later on the patient was found to harbour a tape-worm.

negative. Glands still enlarged. No ill-effects from the chrysoidine which was continued in the same doses.

June 23rd. Very well, save for the fact that he had developed condylomata on the scrotum and round the anus. He had again to be put on anti-syphilitic treatment. Examination of peripheral blood negative.

3 c.c. venous blood inoculated subcutaneously into Monkey 11 (*vide infra*).

July 3rd. Blood count. R.B.C. 3,800,000.

Leucocytes 9,600.

The treatment was continued till about the middle of July, when Captain Browning went on leave, and the patient was sent to the Civil Hospital to be treated for syphilis. I returned from leave in October, and the boy again came under my personal observation. Chrysoidine had not been given in the interval.

October 17th. Looks well. Weight 107½ lbs. Glands in neck still enlarged. Gland juice negative. No trypanosomes found in one blood film, but a few were present in a second.

October 20th. Given ½ grain Merck's chrysoidine in suspension. This was continued daily down to October 31st, when it was stopped because albumin was found in the urine which had become of an intense orange-yellow colour. No casts were present. During the interval trypanosomes were not found, but owing to press of other work the number of examinations was limited.

October 31st. After a long search one trypanosome was found in a blood film. It presented a normal appearance. Chrysoidine stopped as albumin rather copious. Up to date (December 18th) the drug has not been resumed.

November 4th. It was noticed to-day that the glands above and behind the jaw angles had become enlarged, this constituting a new symptom. The boy seemed well and continued so till November 15th, when an attack of diarrhœa pulled him down to some extent. No trypanosomes had been found in his blood and the albumin was gradually disappearing from his urine. Its colour also gradually lessened in intensity. No casts were found at any time.

November 14th. Diarrhœa checked. Weight 102 lbs.

November 20th. Weight 106 lbs. Boy looks well and is fatter. No trypanosomes found in peripheral blood.

November 25th. To-day the patient had fever and a headache. On examination of his blood, ring forms of the malaria parasite, apparently quartan from their shape and structure, were found. No trypanosomes were present. 10 grains of quinine sulphate were given. The malaria was probably a recrudescence of an old attack.

November 26th. Temperature 99·5° F. 10 grains quinine given.

November 27th. Temperature normal. Much better. Urine now quite free from albumin, blood free from parasites.

November 30th. Gland puncture negative. Boy looks fat and well.

December 1st. A single trypanosome found in one film. A second film proved negative.

December 6th. A distinct increase in size of the glands behind the ascending ramus of the left jaw noted; otherwise the patient seemed well and lively.

December 17th. Weight 105½ lbs. No trypanosomes found nor had they been present since December 1st. Glands still big. The case is still under observation, and I do not think we can form any conclusion from it, though I have recorded it at some length. Dr. Neave seems certainly to have found that a rapid and marked decrease of

trypanosomes and a general improvement in health followed the exhibition of chrysoidine, and his observations were confirmed by Dr. Baker. I have observed that the dye does seem to cause a disappearance of the parasites both from the peripheral blood and the gland juice, but then the patient has been removed from a trypanosome area and the chance of

FIG. 75.—UGANDESE BOY "Wariga"
(Photographed at Khartoum during treatment)

of further infection, has been well-fed and well-clothed and has been carefully treated for syphilis. Further, human trypanosomiasis in its early stages is, as a rule, a very chronic affair and the parasites appear and disappear of their own accord in the peripheral blood. I feel that I cannot commit myself to any opinion so far, though I have also a monkey experiment as a control. It would seem that chrysoidine is distinctly irritating to the kidneys and has to be used with caution.

February 12*th*, 1906. Trypanosomes were again found in the glands and began to increase in number in the peripheral blood. Chrysoidine has, therefore, been started once more. It is being given by the mouth in the same doses. The boy's general condition is excellent. If marked improvement does not result it is proposed to exhibit arsenic and trypan red possibly combined with atoxyl.

Inoculation experiments with *T. gambiense*

Monkey 9. (*Cercopithecus sabæus*). Weight 3·1 kilos.

June 9*th*. Inoculated with 1 c.c. venous and citrated blood from above case.

The blood was examined with negative results down to June 14th, when the temperature of the animal was found to be high.

June 15*th*. Found dead. *Post-mortem*. Pulmonary congestion, and an acute pleurisy were found. There was no evidence of trypanosome infection. Bacterial invasion had occurred.

Monkey 11. Weight 2·2 kilos. Temp. 104·4° F. at midday.

June 23*rd*. Blood examined and found free of any parasite infection. Inoculated from case of Wariga with 3 c.c. venous and citrated blood given subcutaneously.

July 7*th*. Trypanosomes found for the first time. Afternoon temperature 103·3° F. In the interval the temperature (rectal) had ranged from 103·1° to 105·1° F. There were not many parasites present, but on August 17th an increase in their number was noted by Captain Ensor and Mr. Friedrichs, who were making observations in my absence.

September 5*th*. No trypanosomes were found by Mr. Friedrichs after a long search.

September 30*th*. One trypanosome was found after a long search. My next note was made on

October 18*th*, when I found trypanosomes present and, as a control, inoculated Monkey 18 with ·5 c.c. blood. It may be stated here that this monkey's blood, when examined on November 28th, showed a few trypanosomes. None had been present twenty days previously.

October 19*th*. Treatment with chrysoidine begun on Monkey 11. Given 1 grain (·0648 gram), Merck's product in 1 c.c. sterile distilled water. Weight, 2 kilos.

October 20*th*. Urine yellow. A few trypanosomes present, 6 or 7 in the stained film No change apparent in them. 1 grain given.

October 21*st*. Animal did not get a full dose. About 4/5ths of a grain given. Trypanosomes appeared to be slightly less numerous. (Plate XIV., Fig. *b*).

October 22*nd*. A distinct diminution in the number of trypanosomes. Only two were found in the film after an exhaustive search. They were apparently unchanged. 1 grain given.

October 23*rd*. No trypanosomes found after prolonged search. 1 grain given.

October 24*th*. Several trypanosomes found in film. 1 grain given.

October 25*th*. Monkey appears to be getting somewhat thinner. Blood showed a few trypanosomes present which seemed to take the stain feebly. 1·5 grain given.

October 26*th*. As above. Animal lively. 1·5 grain given.

October 27*th*. One unaltered trypanosome found after a long search. 1·5 grain given.

October 28*th*. One film showed no parasites. In a second, one trypanosome was found. 1·5 grain given.

October 29*th*. One trypanosome found in film. 1·5 grain given.

October 30*th*. A drop of blood which exuded from the needle puncture and was mixed with chrysoidine was examined. The red corpuscles were found to be disintegrated. No parasites were seen. 1·5 grain given.

October 31*st.* A large film carefully examined. No trypanosomes found. 1·5 grain given.

November 1*st.* Weight, 2 kilos (no loss). 1·5 grain given.

November 2*nd.* Blood examination negative. Animal well and lively. 1·5 grain given.

November 3*rd* to 5th as above. Chrysoidine then stopped.

November 6*th.* Blood negative.

November 7*th.* One trypanosome found in film.

November 8*th.* Blood negative. Urine examined and no albumin found. 1·5 grain given.

November 9*th.* No dose given.

November 10*th* to 13th. 1·5 grain daily. No trypanosomes found. Myelocytes noted for the first time. Monkey well and strong.

November 14*th* to 18*th.* Same dose given daily. Occasionally one trypanosome found per film. Weight on November 18th, 1·9 kilos.

November 19*th.* Two grains given.

November 20*th.* Two grains given. Blood negative.

November 21*st.* Two grains given. Blood negative. Animal well.

November 22*nd.* Two grains daily. One trypanosome found per film on 22nd and 24th. At this stage considerable anæmia of the mucous membrane, as evidenced by pallor of gums and palate, was noticed. There was some œdema of scrotum and sheath.

November 25*th.* Two grains given. Blood not examined.

November 26*th.* No dose given. Œdema of scrotum marked. Weight, 1·9 kilos.

November 27*th.* There was apparently some slight septic infection of the foot following the needle puncture made to secure blood for examination. The mid-day temperature, however, was only 102·8° F. No dose. No albumin in the urine.

November 28*th.* No note.

November 29*th.* Monkey better. Blood negative after exhaustive search. No dose given.

November 30*th.* One trypanosome found in film. No dose given.

December 2*nd.* One dividing form found in the blood. A slight necrotic patch apparent at the common seat of inoculation. Though the animal was well and lively, despite the local sore, it was thought better not to resume treatment. The blood was not again examined till December 20th, when it was found that a distinct increase of trypanosomes had taken place. Four were found in a film after a very brief examination. The monkey looked well, and the wound which had suppurated slightly had nearly healed.

The animal remains under observation, but I think that, taken in conjunction with Wariga's case, the results are of such a nature that chrysoidine might be given an extensive and thorough trial in places where human trypanosomiasis is prevalent. It seems to cause a lessening in the number of the parasites present in the peripheral blood, and the general condition possibly improves under its use. Its tendency to bring on albuminuria is a disadvantage. I admit, however, that no definite conclusions can be drawn from these two cases in man and monkey. Trypanosomiasis due to *T. gambiense* is generally a very chronic disease, and the action of chrysoidine would have to be observed over long periods, and in a large number of cases at different stages of the disease and under varying

conditions. The temperature of the monkey, which was taken daily, appeared to bear no reference to the number of trypanosomes present in the peripheral circulation.

Treatment with Blood Serum.—Dr. Sheffield Neave on arrival at Khartoum informed me that he was anxious to test the therapeutic effect of the blood-serum of wild animals from trypanosome infected districts on experimental animals inoculated with trypanosomiasis. He had prepared a special apparatus for collecting blood and permission was obtained from H.E. The Governor General to shoot some of the more common buck for the purpose of obtaining their blood serum.

The blood-serum of big game as a method of treatment

It was not long before Dr. Neave sent me a sample of blood serum from a water-buck (*Cobus defassa*), free of trypanosomes, shot on January 27th. The serum arrived in good condition, a small quantity of carbolic acid having been added to it as a preservative.

I proceeded to test it in vitro and found that added in equal quantities to citrated blood containing the trypanosomes of mules, it caused agglutination in the form of irregular rosettes, the motility of the trypanosomes making up the rosettes remaining. After 30 minutes there was marked agglutination. Disintegration and death of the parasites also occurred. I was unable to employ the serum until March 18th when it was used in

Exp. 10. Monkey 3. *March 18th.* Animal very ill. Blood swarming with trypanosomes. 1 c.c. blood serum injected subcutaneously.

March 18th. Monkey suffering from spasticity and tremors. Collapsed. Reflexes increased.

Eyes fixed, no strabismus or face twitching. Hamstrings retracted. Blood showed conjugating? (possibly dividing) and agglutinating forms, the agglutination masses being small. 2 c.c. serum given. The trypanosomes thereafter underwent disintegration. In many cases, on staining, nothing was to be seen except the centrosomes with flagella attached. Involution forms were also present. Two hours thereafter there was a general increase of the spasms and the animal was chloroformed.

The post-mortem findings have already been detailed to some extent (p. 137). In smears made from the splenic pulp strangely altered forms were found, some, probably young resistant forms, approaching very closely to the Leishman bodies in appearance, but the short chromatin rods were not found in any of them. Some were clearly dead or degenerated forms.

Exp. 14. Gerbil 2. *March 20th.* Blood swarming. Animal wonderfully healthy in appearance. Weight 29 grams.

5 minims serum of water-buck injected subcutaneously.

March 21st. 5 m. given. Slight agglutination noted.

March 22nd. 5 m. given. Both forms present. Sluggish. Many soon became motionless. After the inoculation a remarkable agglutination and breaking down of trypanosomes occurred.

March 23rd. Gerbil looked thinner. Not so well. In fresh film many motionless forms found. Disintegrated forms not so marked in stained specimen. 10 m. given.

March 23rd. Found dead. In the heart's blood curious spherical forms, some showing marked vacuolation, were found. The same were present in smears from the liver.

Exp. 17. Monkey 4. *April 4th.* Blood full of trypanosomes. Both forms well marked.

April 5th. 1 c.c. serum of water-buck injected subcutaneously.

April 6th. 1·5 c.c. given. No change in blood.

April 7th. 2 c.c. given.

April 8*th*. A lessening in the number of trypanosomes noted. Mostly short forms present, which were sluggish. On staining, these were found to show many granules, and to possess vacuoles. 2·5 c.c. given.

April 9*th*. Not a single trypanosome found, either in fresh or stained preparations. 2·5 c.c. given.

April 10*th*. Monkey well. Shows no sign of the disease. A few trypanosomes found.

April 11*th*. Condition much the same. Three distinct forms observed. (*a*) Typical long forms. (*b*) Typical short forms. (*c*) Intermediate forms with rather short flagella. A few involution forms, some with swollen posterior ends. 3 c.c. given. The long forms, some of which were in process of division, all appeared to be of the same kind as regards general shape, length of flagella and size of centrosomes and nuclei. There was nothing to lead one to suppose that male sexual forms were present in the blood. The intermediate forms (*c*) were probably merely some of the usual short forms in which the flagella were more developed than is customary. None of the short forms were dividing, and in no case was the flagellum of any great length.

April 12*th*. No change. 4 c.c. given. 2 c.c. in morning, 2 c.c. in afternoon.

April 13*th*. No change. 4 c.c. given.

April 14*th*. Only 3 c.c. given in one dose to-day.

April 15*th*. 5 or 6 lively trypanosomes per field. Appearance as of "tadpole" forms. 4 c.c. given in two doses.

April 16*th*. No change. Mostly long forms in blood. 6 c.c. given in two doses.

April 17*th*. In fresh film one sluggish long form found after a long search. In stained preparation some short forms evident. Most seen three per field. 6 c.c. given.

April 18*th*. Much as above but more numerous, there being as many as 12 in one field. (Leitz, Oc. 4, oil imm., $\frac{1}{12}$th.)

April 19*th*. No change. No increase. Vacuoles very apparent. 8 c.c. given in two doses.

April 20*th*. In fresh film no parasites found after a long search. In stained preparation a few unaltered forms found after a considerable hunt for them. Animal well. Weight 2·6 kilos, being a gain of ·2 of a kilo from commencement of experiment. 8 c.c. given.

April 21*st*. A single morning dose of 6 c.c. given.

April 22*nd*. No change. 10 c.c. given, in two doses.

April 23*rd*. Trypanosomes as numerous as ever. 10 c.c. given.

April 24*th*. Trypanosomes apparently increasing in number. 12 c.c. given. The serum, which had acquired a peculiar odour, had probably undergone some change, and become inert. Treatment was accordingly discontinued. Thereafter a steady increase took place in the number of parasites, and the monkey began to lose weight (2 kilos on 29th) and go down-hill.

May 1*st*. Found dead. Bacterial invasion. An ulcer was found in the cæcum. No erosion of stomach. Liver and spleen not markedly congested. Mesenteric glands enlarged.

Smears from spleen, liver, lung, bone-marrow, and glands negative, owing to bacterial invasion.

Exp. 18. Gerbil 11. *March* 29*th*. Both forms present and numerous. 10 m. given subcutaneously.

March 30th. Trypanosomes more numerous. Long typical forms, thick intermediate forms, without flagella and blunt, or somewhat pointed at posterior ends, and tiny short forms seen. The distinctions were well marked. 15 m. given.

March 31st. 15 m. given. No change.

April 1st. 20 m. given. No change.

April 2nd. 20 m. given. Animal very ill.

April 3rd. Found dead. Although no abscess formation had occurred, from the state of the tissues round the site of inoculation I am inclined to think this animal may have died of sepsis. The post-mortem results have been reported. Nothing was found save a bacterial invasion of the tissues.

Exp. 25. Monkey 6. Weight 1·3 kilos.

May 5th. Trypanosomes numerous, 20 or 30 per field. Both forms present. Long forms in process of division.

May 6th. On this date, being the thirteenth day after inoculation, 7 c.c. of blood serum of water-buck of date January 27th, 1905, were injected subcutaneously. Blood taken 5 hours after inoculation. Fresh blood swarming with very active parasites. Animal's condition unchanged. On staining, it was found that, while the majority of the trypanosomes were unchanged, some had completely broken down, their centrosomes, free edges of the undulating membranes and flagella alone persisting. Many curious forms, some with huge undulating membranes were seen. Vacuolated and "shadow" forms present. Short forms chiefly affected.

May 7th. Blood examined during the afternoon. Nearly every trypanosome much vacuolated. Not so many curious degenerated (?) or involution forms present but a greater number of trypanosomes affected to some extent. No change in general condition of monkey. Given 10 c.c. blood serum at 4.15. Blood taken at 5.5 p.m. No change.

April 8th. Fresh film showed living and active trypanosomes of both forms. Long forms do not now appear to be affected. 12·5 c.c. given. Blood examined $4\frac{1}{2}$ hours after inoculation. Extreme vacuolation of short forms noticed. Some of the parasites seemed almost to consist of vacuoles united by thin strands of cytoplasm. Many greatly degenerated forms (Plate XIV., Fig. *d*).

May 9th. Blood in much the same condition. Some loss in differential staining as regards the parasites. About 19 c.c. given in four separate doses. After half an hour the monkey was evidently suffering from giddiness. It appeared to be ill, and made strange, aimless efforts to climb up the side of its cage. Some tremors were observed, together with a transient rigidity of the hind legs. No twitching of face or fixity of gaze. The animal several times fell over on its side but quickly recovered itself. This condition of affairs lasted for $1\frac{1}{2}$ hours. Thereafter recovery took place and the monkey took food freely. The blood examined during the attack and also $4\frac{1}{2}$ hours after the inoculation showed no change in the state of the trypanosomes. The attack was probably due to the large amount of fluid which was given causing a disturbance in the semi-circular canals.

May 10th. Small rosettes of trypanosomes found, many resembling the Manx Coat-of-Arms. Dividing forms present. On staining, degenerate or dead forms were seen. The monkey was better and took its food well, but was somewhat somnolent, and kept its head down as if depressed.

May 11th. Serum treatment stopped. From this time the monkey rapidly went down-

hill. Degenerating forms disappeared in large measure from the blood, and normal trypanosomes increased.

May 14th. The monkey was fouud dead in the morning.

Post-mortem. Stomach. Congested areas found near the pylorus with blood clots covering them. These probably indicated a commencing erosion. Ulceration, blood-clots, and general congestion found in connectiou with six Peyer's patches. In a scraping from one of these ulcerated areas lively spirilla were seen.

No cæcal ulceration or erosion of large intestine. No enlargement of mesenteric glands.

Spleen. Moderately enlarged, firm but congested.

Liver. Only slightly enlarged.

Heart's Blood. A few sluggish trypanosomes. Dead, motionless forms present.

Bone-Marrow. Red, not very diffluent.

Brain. Supra-cortical hæmorrhage over and round about the right Sylvian fissure. The condition was curious, like a thin sheet of blood spread out over the convolutions.

Smears. Heart's blood. Myelocytes, a few normoblasts and a few much altered trypanosomes.

Spleen. A few young forms—as described by Lingard—fouud. Bacterial invasion.

Liver. Normal trypanosomes present. Marked phagocytic action of the polymorpho-nuclear leucocytes. Frequently two trypanosomes engulphed in a white corpuscle were seen Macrophages present.

Brain-clot. Spherical forms of trypauosome noted. Also curiously altered and vacuolated types.

Bone-marrow. Bacterial invasion. No trypanosomes seen.

Intestinal ulcer. No spirilla or trypauosomes found in the stained preparation.

Stomach clot. Negative.

Exp. 28. Gerbil 16. April 20th. Slight infection on this, the tenth day after inoculation. Given 1 c.c. serum of water-buck of date January 27th, 1905, by subcutaneous inoculation at 4 p.m. About 5.10 p.m. the animal was found to be in violent convulsions, lying on its side and kicking vigorously. The cardiac action was rapid. Blood was taken from the tail at 5.30 p.m. Some rounded forms of trypanosome were seen. Chloroform was administered at 6 p.m., and a post-mortem performed immediately.

Spleen and kidneys much enlarged. Liver uot enlarged, but soft iu consistence like the spleen. No ulceration or congestion of stomach.

Smears. Heart's blood. Ordinary and degenerating and broken-down forms. Changes uot extensive.

Spleen, liver and bone-marrow negative. In kidney smear, ordinary unaltered forms were found. Death probably the result of over-dose and intoxication.

The study of such a work as that of Nuttall ou Blood Immunity and Relationship, demonstrates how numerous and how complicated are the problems which arise when one conducts serum experiments.

Questions relating to hæmolysins, agglutinins and precipitins present themselves. True, these may have no direct bearing on the action of sera ou blood parasites, but they have to be considered in relation to the effects produced which may possibly modify such action. Perhaps some of the symptoms noted were due to intoxication, the result of overdosage which is always apt to occur. There seems little doubt but that the serum profoundly affected the trypanosomes, but here again the number of cases was very limited, and uo conclusions can

be drawn. The difficulty is to find time wherein to conduct sufficient experiments. One is often interrupted by work coming in which demands immediate attention, and there is no one at present to whom such work can be passed.

A couple of immunising experiments were tried. In one the animal, a gerbil, died; in the other a jerboa received 10 m. of serum for two days, and then 20 m. every day for eight days, after which it was inoculated from Monkey 5. After an incubation period of two days trypanosomes appeared, and the disease ran its usual course wholly unmodified by the previous inoculations.

Notes on the Pathological Anatomy of Trypanosomiasis.

Until Baldwin* in 1904 directed his attention to this matter in the case of experimental Nagana it had received but little attention. Work by Mott,† Warrington‡ and Low§ has been carried out on the condition of the brain and cerebro-spinal fluid.‖ Laveran and Mesnil deal with the gross appearances in Nagana, Surra, Mal-de-Caderas, and the human disease, and the observers of the Liverpool School of Tropical Medicine have collected much material, but, so far as I know, Baldwin's remains the most important and complete work ont he subject. Since this was written I have seen *Memoir* XVI.¶ of the Liverpool School of Tropical Medicine, which deals very fully with the pathology of trypanosomiasis, and is well illustrated.

Morbid histology of trypanosomiasis

As opportunity offered I have studied the microscopic changes induced in several of the organs by the trypanosomes of cattle and of mules respectively, and a few notes on these observations, which are by no means exhaustive, may be of interest. The sections of liver, spleen, lung, thymus, brain, lymph-glands, gastric mucous membrane, and cornea have been for the most part stained by the hæmotoxylin and cosine method. The cornea sections have also been coloured by the Giemsa process. There has not been time to carry out staining by Leishman's new method though it has been tried in one or two instances.

In the case of Ox 4 the following particulars were noted.

Liver. There was a slight degree of cloudy swelling resulting in a loss of outline of some of the liver cells. These in some instances contained masses of golden-brown pigment which was also present, and to a greater extent, in the endothelial cells. There was marked congestion of the *vasa capillaria.*

Spleen. This presented a very acute congestion of the capillary spaces in the pulp.

The trabeculæ had undergone hypertrophy as had the Malpighian corpuscles. Some golden-brown pigment was present in some of the Malpighian bodies, but it was chiefly found in the pulp.

Lung. Congested. A cellular exudation, chiefly lymphocytic, had taken place into many of the *alveoli.* Others contained a stringy or granular exudate. Certain of the *alveoli* were much compressed and in some the walls were in contact.

Lymph-gland. An enormous increase of lymphocytes was noted. Many young blood vessels were present. Large round cells like those met with in the mesenteric glands in cases of enteric fever, and containing fat droplets and sometimes two nuclei, were observed.

* Journ. of Infect. Diseases. Chicago; Vol. IV., pp. 544-550.
† Brit. Med. Journ. Vol. II., p. 1,666. 1899.
‡ Brit. Med. Journ. Vol. II., p. 929. 1902.
§ Low and Mott. Brit. Med. Journ. Vol. I., p. 1,000. 1904.
‖ Mott. Brit. Med. Journ. Vol. II., p. 1,554. 1904.
¶ Thomas and Brienl. Memoir XVI. Liverpool School of Tropical Medicine. 1905.

In the sinuses large mononucleated cells containing golden-brown (iron-containing?) pigment were present. Pigment was also seen in the endothelial cells of the capillaries.

There was a general and marked hyperplasia of the stroma.

Stomach ulcer. This section merely showed a destruction of the epithelial layer, the erosion extending to the submucosa which had undergone a bacterial invasion and the vessels of which were congested. The specimen was stained by the Leishman method but no trypanosomes could be discerned.

Brain. This was not stained by any special method and did not present any pathological appearance as far as could be told. I did not find any infiltration of leucocytes round the blood-vessels.

In the case of the trypanosomiasis of mules, the organs and tissues of experimental animals such as the dog and monkey were examined.

Liver. Much the same conditions were seen as existed in the liver of the ox, but there was an entire absence of pigment, at least, in the case of Monkey 21 which died on the sixteenth day after inoculation. There was slight fatty degeneration. Congestion was most marked in the sub-capsular region.

Spleen. Extreme congestion of the splenic pulp together with an increase of connective tissue in the Malpighian bodies constituted the most marked changes. Large mononucleated cells containing fat droplets were seen in the splenic sinuses and there was a general hyperplasia of stroma.

Thymus. Examined in the case of Dog 3 and showed a simple hyperplasia of the lymphoid tissue. The stroma was not much increased.

Stomach ulcer. There was considerable erosion affecting the basement membrane. Thrombosis was present and some obliterative endarteritis. In a cross-section of one of the pyloric glands I noticed a tiny cyst? containing oval nucleated bodies which stained quite differently from the surrounding tissue. They had taken on the eosin stain strongly, and their rounded nuclei were deep purple. They somewhat resembled the encysted merozoites of some sporozoan but were difficult to examine properly, some being on a different plane from the rest of the section.

Lymph-gland. The condition was precisely similar to that found in the lymph gland of the ox with the exception that pigment was absent.

Brain. No small cell infiltration of the perivascular spaces.

Cornea. The opaque cornea of Dog 4 was sectioned and examined. Swelling and erosion of the epithelial cells was found together with an infiltration of leucocytes into the inter-lamellar spaces. As a result the lamellæ in some parts had become more widely separated. In addition a pigment deposit was found confined to the more superficial inter-lamellar spaces, but stretching right across the cornea. It was less marked at the centre than elsewhere. Corneal changes

As Baldwin and others have pointed out these changes are evidently the result of an intoxication and probably due to the action of a specific toxine generated by the trypanosomes.

Conclusions.

1. Trypanosomiasis in cattle in the Sudan is due to *T. nanum*, a small trypanosome of distinct type which is probably, but not certainly, peculiar to bovines. It produces a disease which runs a chronic course and may prove fatal. On the other hand, spontaneous recovery may result, especially if the affected animal be removed from the infected area and be well

fed. The calf of a cow which had thus recovered did not acquire the disease on being inoculated with blood from the cow, after recovery of the latter. So far it has not been found possible to re-produce the disease experimentally.

General conclusions and suggestions regarding trypanosomiasis

2. Trypanosomiasis in mules in the Sudan is chiefly due to a trypanosome which one has not been able to distinguish from, and which is probably identical with, *T. dimorphum*, of Senegambia. The disease produced by this parasite is invariably acute and fatal, is accompanied by characteristic symptoms and leads to well-marked pathological changes. Inoculated into dogs, monkeys (*cercopithecus*), rats, gerbils and jerboas, the parasite rapidly multiplies, producing an acute and fatal disorder. Death also results in the case of rabbits and goats, but the disease runs a much more chronic course. Successive and prolonged passage through animals markedly heightens the virulence of this trypanosome, more severe infections occurring and death resulting with much greater rapidity. A solitary experiment seems to show that cattle are immune.

Mules also harbour another trypanosome closely resembling *T. nanum*. Owing to lack of material this trypanosome has not been fully studied, but mules affected with it may apparently recover when placed under favourable conditions.

The trypanosome of donkeys is possibly different to any of the foregoing, but material has not been available for its study. The specimens observed suggested *T. Brucei*.

3. Tsetse flies are the chief, and probably the only, carriers of these trypanosomes. Diseased animals have chiefly come from districts where the tsetse (*G. morsitans*) has been found to exist. Some have come from a region which it is probable that *G. Longipennis* inhabits. Stomoxys flies appear to play no part in the distribution of the disease.

4. Ulceration of the gastric and intestinal mucosa is commonly found in animals dead of trypanosomiasis. It is often hæmorrhagic in nature, and is in all probability due to the action of a toxine. It may indicate an effort on the part of the parasite to leave its host.

5. The occasional occurrence of spirilla in these hæmorrhagic lesions is of interest, but their true significance has not yet been determined. In all probability they bear no relation to the disease.

6. Chrysoidine has failed as a therapeutic agent in infection due to the trypanosome of mules. Its use has been attended with more hopeful results in the disease produced by *T. gambiense*, and it appears to merit a more extensive trial, with or without arsenic, in this latter condition, but it must be given with caution owing to its tendency to irritate the kidneys.

7. The blood serum of unaffected animals from a trypanosome infected area appears to produce a profound effect on the trypanosomes of mules in experimental animals, but the subject is very complicated, and the number of cases observed has been limited. It is probable, however, that the most satisfactory results in treatment will be obtained by experiments with serum, which either naturally contains a trypanosomicide or is induced to manufacture such an anti-body. The use of the sera of cattle which have recovered from infection by *T. nanum* is indicated. The recent work of Schilling * and the results obtained by Klein and Möllers † in this direction are more encouraging, though Laveran's ‡ warning regarding latency and danger of infection has to be borne in mind. Klein's § recent statement regarding a new prophylactic for plague, prepared from the dried organs of animals

* Zeitschr. f. Hyg., Vol. LII., 1905, pp. 149-160.
† Ibid. Vol. LII., 1906, pp. 229-237.
‡ Assoc. Scientif. Internat. D'Agronomie Coloniale, Paris, 1906.
§ Brit. Med. Journ. and Lancet, Jan. 20, 1906.

dead of that disease, has suggested that experimental work on similar lines might be tried in the case of trypanosomiasis. In several particulars the two diseases are far from dissimilar. Each exhibits a blood and glandular infection by a living organism, in each toxines are produced, and there are other points of resemblance which need not be cited here. It is, therefore, proposed to make some investigations in this direction. Preliminary experiments, however, have not yielded any good results, and Herzog has rather upset the prevalent ideas regarding the precise nature of plague (Journ. Trop. Med., 15th Feb., 1906). While dealing with this subject I may say that I intend to test the value of the Malay fish poison *Derris elliptica* as a therapeutic agent in trypanosomiasis. Daniels states that it is very inimical to all low forms of life, while at the same it appears to be comparatively harmless to man. It is therefore just possible that it might prove useful.

Preventive methods on the lines indicated by Todd* and others will be required to check the spread of Sleeping Sickness from the Congo Free State.

Routine Work

This has varied very much in amount. At times it bulked so largely that it was difficult to cope with it properly; at other times considerable intervals would elapse during which very little had to be done.

The number and nature of the examinations performed, and concerning which reports were furnished, are herewith detailed. The period covered is one of fifteen months.

A.	Morbid secretions and excretions	30
B.	Blood examinations	197
C.	Bacteriological apart from (A.)	31
D.	Parasites apart from (A.) and (B.)	10
E.	New growths	7
F.	Other pathological conditions	11
G.	Plant diseases	12

The above figures do not by any means indicate all the cases which have come under notice. In a considerable number, especially of the blood examinations, a verbal opinion has been given, and these are not included. In several directions the value of having a central place where examinations can be made has been shown, as in the case of glanders and strangles in horses, in several cases of diphtheria, in malaria, and in suspected cases of hydrophobia.

Small-pox

Some notes on the cases listed may be given with advantage. Taking first infectious disease, the accompanying photographs (Figs. 76 and 76 *a*) of a case of small-pox which came under my care as Medical Officer of Health, exhibit very well the appearance and distribution of the pustules. Their confluent condition is well shown upon the face. This case contrasts admirably with the accompanying photographs (Figs. 77 and 78) of chicken-pox and an ecthymatous secondary syphilitic rash. All these were taken by Mr. Newlove. The cases were under the care of Mr. Waterfield, and I am much indebted to him for his kind permission to photograph them and reproduce the prints. The case of small-pox has a further interest in that I made an effort to obtain from the pustules the protozöon discovered and described by De Korté.† I found some amœba-like forms characterised by the possession of the highly-refractile, greenish particles (spores ?) which he mentions. My efforts at staining, however, were not satisfactory, and I was unable to carry my observations to any

* Lancet, London, July 7th, 1906.

† Brit. Med. Journ. London, Nov. 11, 1904, also Lancet, London, Dec. 24, 1904.

Fig. 76.—Case of Small-pox, Confluent on Face

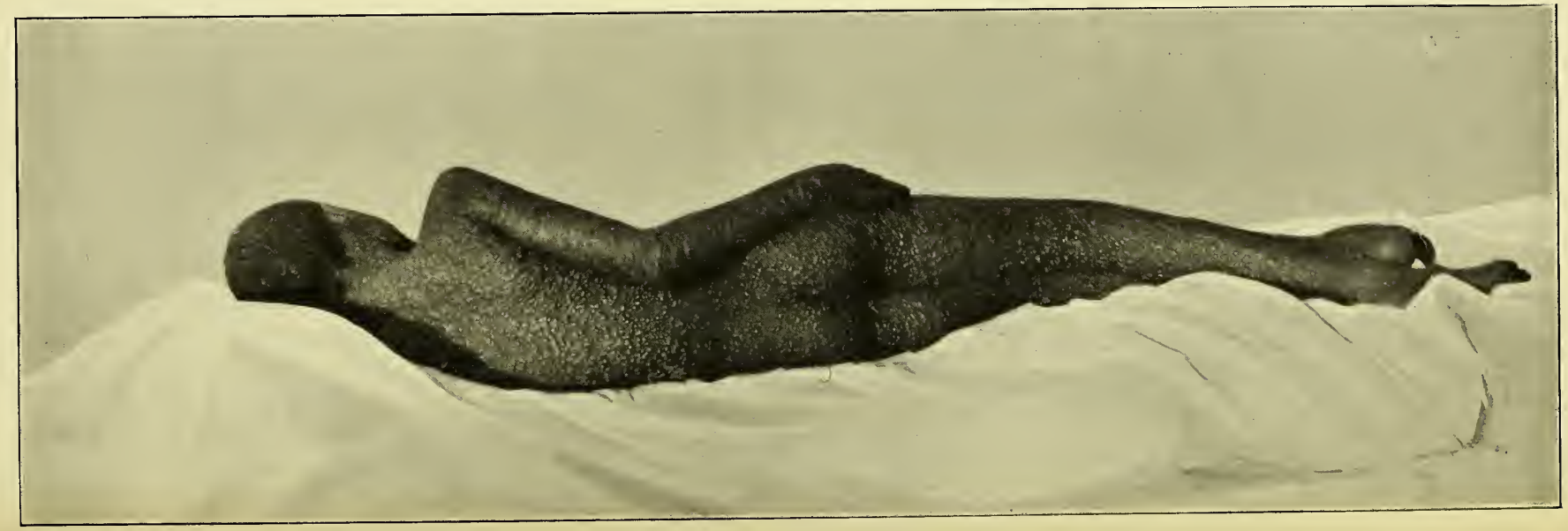


Fig. 76a.—Small-pox, Back View of Patient

definite conclusion. The examination was difficult owing to the vast number of leucocytes of different kinds present in the variolous matter. It was not easy to distinguish the amœba-like forms from some of these cells.

Hydrophobia

Rabies has occurred in Khartoum, and there has been one case of human hydrophobia. The value of keeping and watching any animals bitten by a rabid dog was demonstrated

Fig. 77.—Woman with Chicken Pox
Note the tribal marks on the arms

when a rabbit, inoculated with an emulsion made from the medulla of the rabid dog, died, apparently of latent rabies, just before it might have been expected to show symptoms. The test thus failed, but two bitten dogs which had been preserved alive developed typical symptoms, and so put the diagnosis beyond doubt.

Several cases of diphtheria came under notice. The Klebs-Löffler bacillus was found

Diphtheria

together with streptococci. The disease was of a very severe type and proved fatal in every instance. Its incidence was limited to native infants and young children.

The Widal test has had to be done in a few instances. As previously stated enteric fever is at present a rare disease in Khartoum, despite the fact that the present water-supply

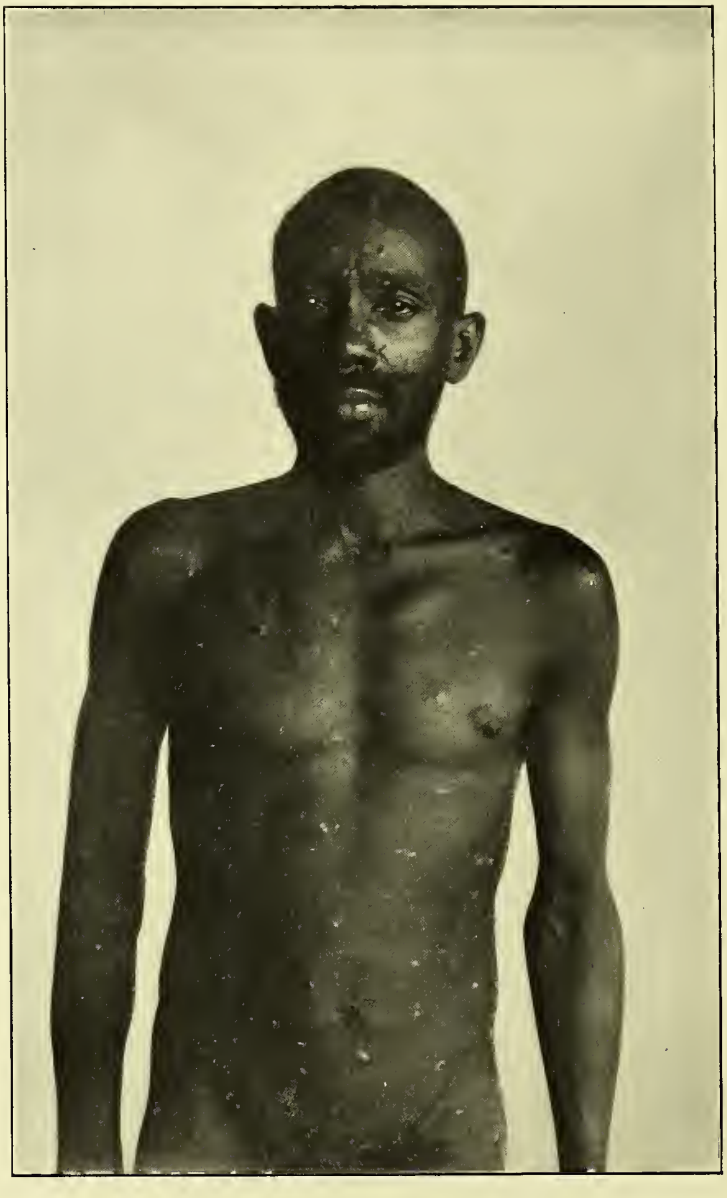


Fig. 78.—Ecthymatous Secondary Syphilitic Rash

can readily become contaminated, and that the system of sewage-removal is offensive and dangerous, and requires to be thoroughly remedied.

Enteric Fever

The native Sudanese must suffer but rarely, if at all, from the disease, and Egyptians are not liable to infection. Sandwith,* however, has shown that they may become so, and now that the new railway to Port Sudan is an accomplished fact, and the isolation of

* The Medical Diseases of Egypt, 1905, pp. 52 and 53.

Khartoum less complete, the danger of an increase in enteric fever as well as of an invasion by cholera and plague, must be seriously considered. Happily this has been recognized and funds are forthcoming for carrying out an improvement in the existing conservancy system.

Dysentery

Dysentery of a bacillary type is not uncommon amongst the Egyptian soldiery, though bilharzia of the rectum is apt to be mistaken for it. In a specimen of the large intestine from a rapidly fatal case of dysentery sent by Major Rivers, an acute congestion of the mucosa closely resembling a measles rash was very evident.

The malaria cases have already been discussed. I have found the accompanying table compiled from various sources, so useful in distinguishing between the various young forms of parasite, that I introduce it here:

Differences Between Early Forms of Malarial Parasite

——	Quartan.	Benign Tertian.	Malignant.
Size, shape and colour of red corpuscle ...	Normal.	Enlarged, pale, distorted. Schüffner's dots.	Circular. Colour often deeper. Smaller.
Pigment	Seen early. Coarse. Often peripheral and opposite chromatin.	Not easily seen in ring.	Not easily seen in young ring. May be marked and gritty in old ring.
Position and shape of chromatin ...	Well inside periphery, at first in a lump, then in diffused dust. Four separate dots, even in young spores.	One round lump situated excentrically but not on edge of parasite. Most frequently close to, or surrounded by, the unstained nucleus or vacuoloid space.	Splash or streak on periphery of parasite. Angular look. Sometimes two small dots like door-knocker hinges. Knocker-shaped ring as sign of special malignancy.
Size	Moderate.	Large.	Small.
Protoplasm	Most.	Thin. Thinnest opposite chromatin. Often badly defined margins.	Thin. Well-defined.
Numbers	Single.	More than one is rare.	Multiple infection common.
Stippling...	Nil.	In all but very young. Schüffner's dots.	Sometimes dark stippling, not red Schüffner dots.
Position	Central. Often stretches across corpuscle as it grows.	Not peripheral. Irregular. Eye-form common after ring stage.	Hangs on to edge. May be only a red streak of chromatin. Looks as if stuck on.

In one instance, a case apparently of malaria epileptica under the care of Captain P. Evans, R.A.M.C., we found a condition recalling the conjugating forms which have been described by Ewing.* The parasite in question was benign tertian. Another interesting case, from the point of view of differential diagnosis, was also in the charge of Captain Evans, and I have to thank him for permission to make mention of it. A sputum was sent for examination, as its peculiar

A question of differential diagnosis

* Clinical Pathology of the Blood, 1903.

coffee-coloured appearance, its consistence and the absence of froth suggested that it might be due to a liver abscess rupturing into the thoracic cavity. The symptoms of the case were indefinite and might easily have been induced by such an hepatic condition. On examination some polygonal cells were found and clumps of staphylococci. Elastic fibres were not seen. Von Jaksch* states that if free hæmatoidin be present in considerable quantity the inference is that an abscess has discharged from some neighbouring organ into the lung. Free hæmatoidin was present in this case but only in very small amount. No definite opinion could be given but it was admitted that the case was suspicious. It proved rapidly fatal, and the history, which had at first not been easy to obtain, and the post-mortem examination revealed the true state of affairs. The patient had received a kick on the calf of the left leg and this had resulted in thrombosis of one of the deep veins. In some unknown way the thrombi had become septic and had been carried by the blood stream to the lungs. Pulmonary embolism with rapid breaking down of one of the embolic areas had taken place,

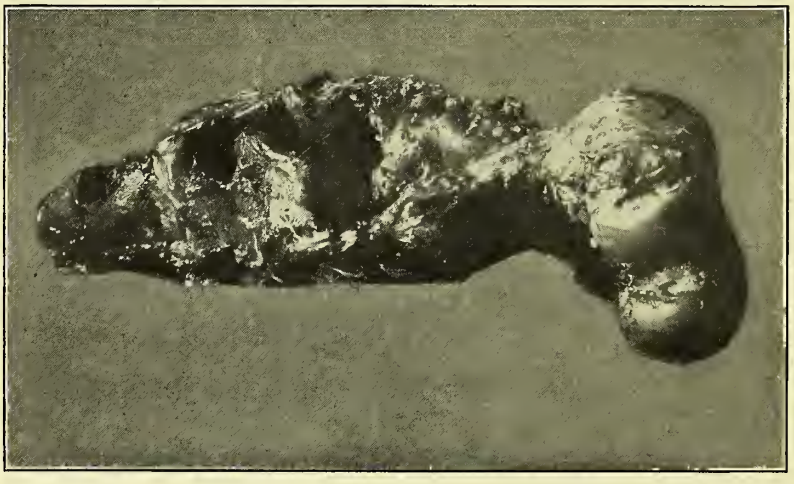


Fig. 79.—Hydatid of Femur, causing extensive erosion of the bone.

both lungs being infected. I do not think that such a condition has been previously mentioned as occurring in connection with the differential diagnosis of hepatic abscess.

Parasites

As regards the larger parasites, *Strongyloides intestinalis* has come under notice, but the most interesting observation was made in a case seen by Captain Hughes at El Obeid in which the patient passed two worms in his urine. These were sent to the laboratories and proved to be *Trichocephalus trichiurus*. I did not know that this nematode had ever been discovered in the urine, but I found that Boston,* in his recent work on Clinical Diagnosis, mentions the occurrence of its eggs in human urine. There was no doubt in this case but that the worms had been expelled *per urethram*.

Hydatid of bone

The accompanying photograph (Fig. 79) is that of a human femur which was infected by hydatid disease. The specimen was sent by Captain Cummins, who intends to describe the case in the R.A.M.C. Journal. Hydatid of bone is sufficiently rare for this instance to merit attention here, and Captain Cummins has kindly granted me permission to mention it. The photograph was taken by Dr. Beam, and the specimen is in the laboratories' museum.

Avian disease

In turkeys dying in Khartoum tuberculosis and aspergillary pneumycosis have been

* Clinical Diagnosis, 1899, p. 135.

observed. In the latter disease the curious bossy white plaques produced by *Aspergillus glaucus* were present, not only on the pleuræ but also on the pericardium and peritoneum.

Miscellaneous Notes.

The blood of a considerable number of bats, birds, and fish have been examined. In the case of the barn owl *(Strix flammea)* caught in Khartoum, and in the bloods of sparrow-like birds at Taufikia, Halteridia were present, as also in the blood of a guinea-fowl brought me from the Blue Nile by Mr. Broun. In the blood of another guinea-fowl sent from the Bahr-El-Ghazal by Major Dansey Browning an Hæmamœba, like that described by Dr. Neave (p. 200), was present, while in a blood film from the Blue Jay, also sent by him, another and possibly different Hæmamœba was found. I am inclined to think that Leucocythemia may be found to be a fairly common disease in Egypt. I have seen two cases in Egyptian soldiers in Khartoum, and several others at Abassieh, Cairo, along with Captain Cummins, E.M.S. The bloods of these cases were typical and the symptoms were fairly well-marked, splenic enlargement being constant.

The testing of chrysoidine on the ciliated embryo of *Schistosomum hæmatobium* has been mentioned. A solution of 1 in 20,000 was found to kill the living and active embryos instantaneously, and it was noticeable that, on death occurring, the stomach became everted and protruded from the motionless parasite like a beak. 1 in 200,000 proved fatal in 17 minutes.

It was found that, despite the addition of solutions of 1 in 10,000 and 1 in 100,000 to urine samples, the embryos developed from the eggs but these embryos were immediately or speedily killed. It was curious to note that in some cases the nervous system of the myracidium took on the stain more intensely than the surrounding tissues. The solutions were made in distilled water, the effect of which had been previously tested on the embryos and found to be negative. Controls were carried out in every case. At my request Captain Ensor, E.M.S., tried chrysoidine in two cases of bilharziosis and he reported favourably on its use, telling me that the men had greatly improved. I then tested it on two cases kindly placed at my disposal by the S. M. O. Khartoum, but I failed to find that any benefit resulted. I had hoped by observing the eosinophile count to see if any effect was being produced on the parasites. In one case the number of eosinophiles did lessen markedly; in the other, slight increase occurred. It was, perhaps, hardly to be expected that enough of the dye-stuff to affect the parent worms could be introduced into the system without pushing the remedy to a dangerous extent.

Experiments with the *Schistosomum hæmatobium*

Some other observations have been made in connection with Bilharziosis. In the First Report the prevalence of the disease amongst the boys attending a primary school in Khartoum was mentioned. Many of these boys drank water from the school well and this water was submitted to examination. A tiny but very active Entomostracean probably belonging to the Order *Ostracoda*, just visible to the naked eye, was seen, and it was thought worth while to place some of the myracidia along with these crustaceans in a watch-glass and observe what happened.

Six active embryos were placed in water along with three of the lively crustaceans and left over night. In the morning one dead embryo was found lying on the foot of the watch-glass, the other five had wholly disappeared, and the crustaceans remained alive and active. What had become of the missing five? Presumably they had entered or been taken up by

the crustaceans. These latter were watched for several days, till they died in fact, and were then examined. Nothing developed from them, and nothing was seen on separation of their shells. One has not been able so far to make any further experiments in this direction. Assuming that the initial observation and deduction were correct, and there was no opportunity for error to creep in as far as one can see, these crustaceans, which have not been fully identified, would require to have their hard shells decalcified, and then be examined in serial section, before and after being in contact with the bilharzia embryos. The method of examination would be both difficult and tedious, but it might repay the time spent upon it. I hope to repeat the original experiment and investigate the subject more fully. In this connection Loos's suggestive work on Bilharzia has to be remembered, while, granting that these crustaceans are *Ostracoda*, one must not forget that the members of this genus are said to be flesh-eaters, which might account for the apparent act of ingestion.

I had intended giving details of calculations carried out at the request of the late P. M. O. of the Egyptian army with the object of discovering whether a dietary of meat, vegetables and dura (millet), could with advantage be substituted for one of meat, vegetables and wheat flour, for the men of Sudanese battalions. I learn, however, that the recent researches of Chittenden embodied in his work entitled "*Physiological Economy in Nutrition*" have "clearly shown the necessity of materially modifying the views on diet requirements in health that are given in old and recent standard works on diet" (Chalmers Watson). Consequently, until one becomes familiar with these altered views it would probably serve no purpose to introduce the tables and deductions which I had prepared.

In concluding this, the part of the Second Report,—for which I am personally responsible—I would take an opportunity of expressing my indebtedness to Dr. Beam for his excellent photographic work, and to Mr. Butler, Director of the Game Preservation Department, for kindly identifying various mammals and birds for me. Mr. Friedrichs has rendered useful assistance in animal experiments and latterly in museum and histological work. My thanks are due to Mr. Theobald and Mr. Austen for much kind help, and to Mr. Richard Muir for the great care and trouble he expended in the preparation of the numerous plates. Mr. Macduff Simpson has been good enough to aid me very considerably in the correction of proofs.

Acknowledgments

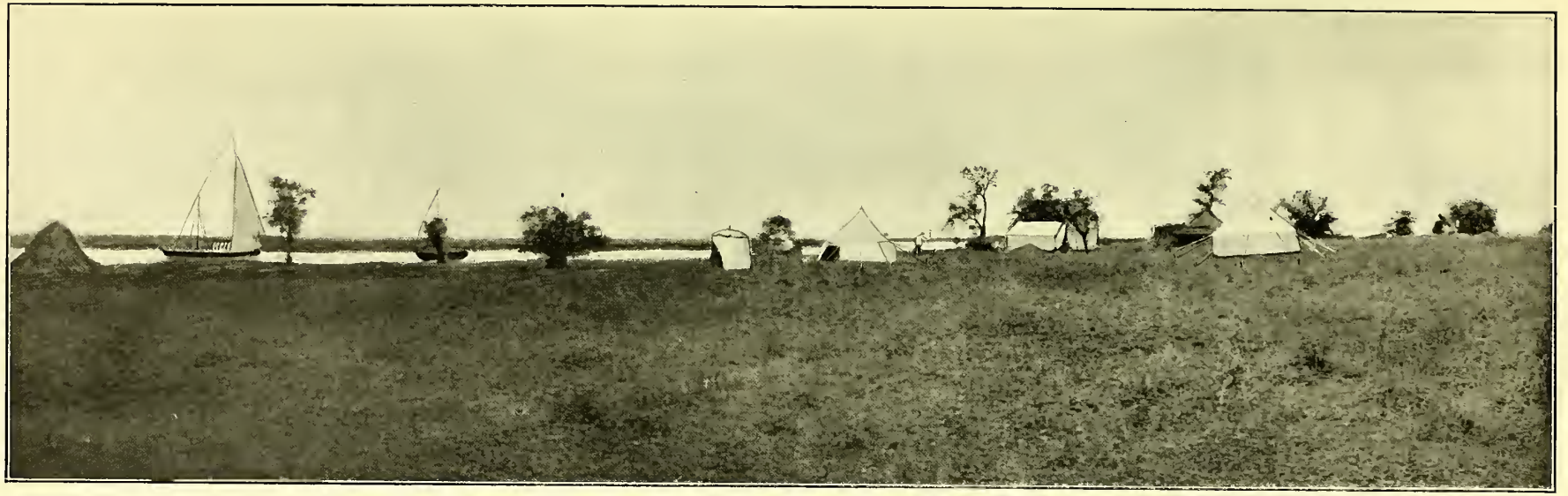


Fig. 80.—Camp at Luala's. Gyassas on River

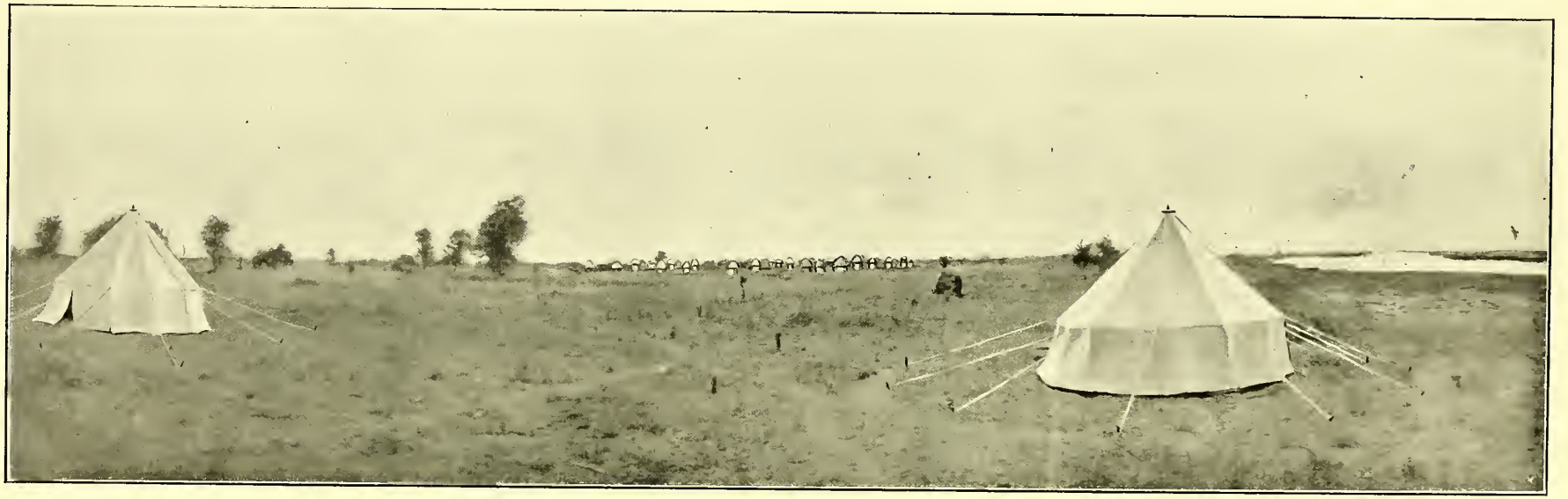


Fig. 81.—Camp at Luala's. His Village in Distance

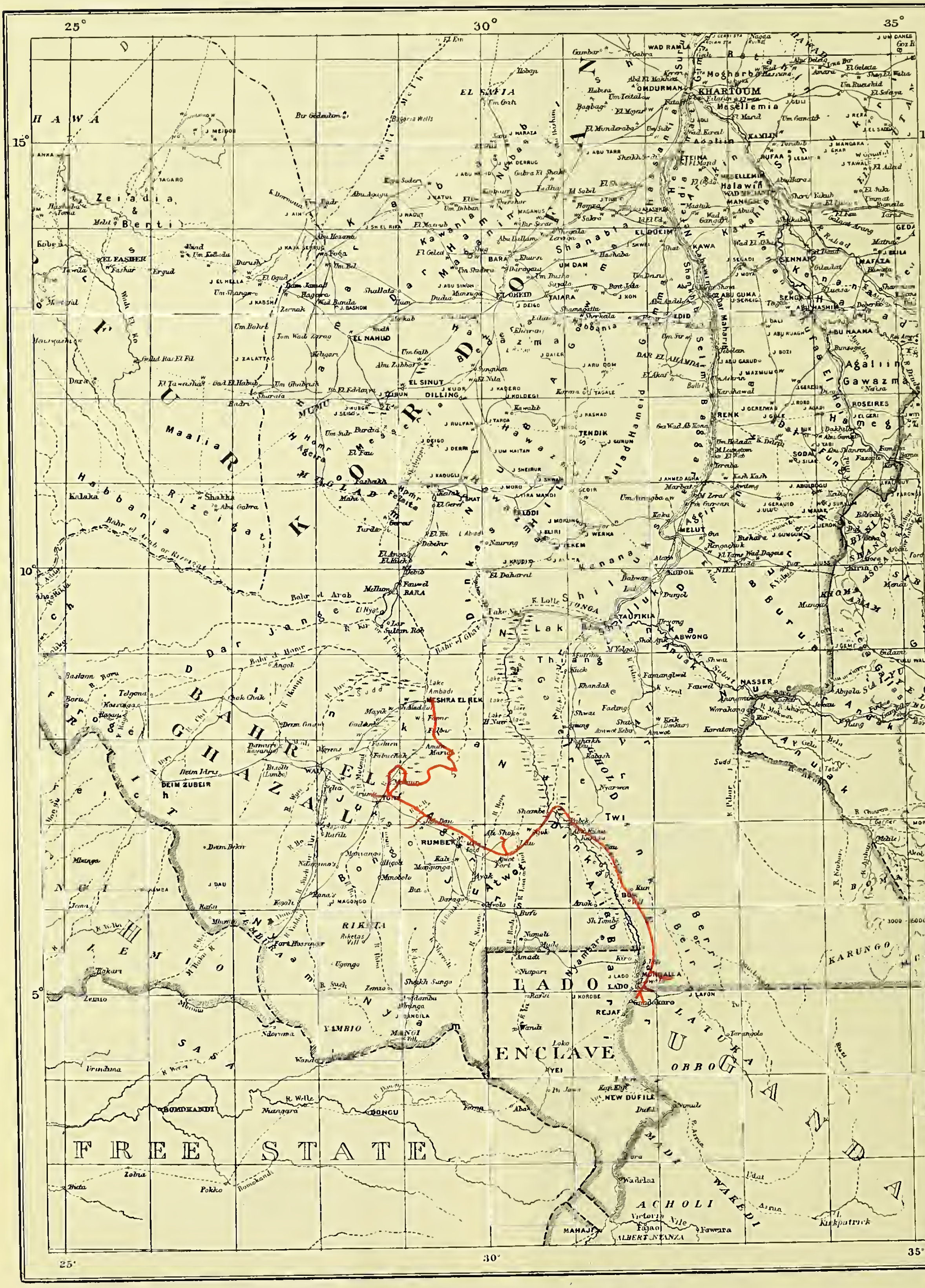


Fig. 82.—Route of Travelling Pathologist, 1904-5

Report of Travelling Pathologist and Naturalist

BY

SHEFFIELD NEAVE, M.R.C.P., M.R.C.S.

General

I left England on 11th November, 1904, having spent some six weeks in collecting outfit. Scientific apparatus is very difficult to collect hurriedly, makers are few, and independent in their methods, and it was only with great exertion that I got most of it shipped before I started. Much I was unable to inspect and consequently some of it was not satisfactory.

On arrival in Cairo I wished to get hold of my outfit and urge on its despatch to Khartoum, as shipping and railway delays are proverbial. I was, however, ordered to Khartoum at once.

On arrival at Khartoum, I had to wait for my outfit for 23 days; this delayed my start till the 16th of December, and necessitated my taking with me the whole three years' supply unsorted and much of it in bulk, with parcels not labelled. Some packages were missing and did not reach me till my return.

While in Khartoum, besides the necessary preparations, I spent most of my spare time in studying the mosquitoes known to the Sudan.

Plan of Expedition

On 16th December, 1904, I left by the "Dal," S.W. for Gondokoro under orders to meet Captain Greig, I.M.S. of the Royal Soc. S.S. Commission in Uganda, and confer with him as to the investigation of the distribution of *Glossina palpalis*, and then to proceed to carry out the same in conjunction with him. I was also to take every opportunity of examining the blood of men and animals as regards infection by blood parasites and to secure specimens of biting flies, etc. I was also to study disease generally and collect specimens of animal and vegetable life and articles of interest, and to obtain any information likely to be of medical or economic value, and to observe and note native customs, etc., as far as possible.

To this end I was to commence by camping in the neighbourhood of villages and obtain the confidence of the inhabitants by means of gratuitous medicine and surgery and otherwise. After exploiting the Bahr-El-Jebel from Gondokoro to Shambé, I was to proceed to the Pongo River, etc., in the Bahr-El-Ghazal.

To have done this properly would, I reckon, have taken some two years, but owing to delays and to the necessity as I then thought of returning to the Sudan by the following November, I only had some four months to spend between Gondokoro and Meshra-El-Rek. It is a matter of regret to me that I was not aware that this was to be my only journey, as I would have prolonged it by two months at a very small expense compared to the total.

My assistant, on whom I relied for collection and skinning, etc, did not consider himself qualified for the work, but was very useful and obliging in every other way. Later he had to return, seriously ill. Thus my power of carrying out these directions was very limited, and it is due to the richness of this field for investigation that I achieved such results as were attained.

Duration of

I was 127 days absent from Khartoum, and of these I only had 40 for actual scientific work, the remainder being occupied in travel and search for tsetse fly, and this although I did not miss a single day for work, thanks to being fortunate enough to keep my health.

Medical work amongst Natives

The idea of medical work among the natives as a means to an end had to be largely abandoned, in fact, given up almost altogether, as patients paid but one visit, or at the most, two, and expected to receive the necessary cure without further attention, and it would have required a residence of some months in one place before really gaining their confidence. An exception to this lay in the case of those who received a special sort of cough lozenge, the taste of which was much admired. One sheik, I am sure sent half-a-dozen of his subjects every day to complain of cough, in order that he might have them as sweetmeats.

Fig 83.—Gyassas of Dr. Neave's Expedition

The result of this position was that I had to adopt a different method of procedure for which I was not so fully prepared and which I had intended to be merely subsidiary.

Bahr-El-Jebel. Glossina

Arrival at Gondokoro

Capt. Greig had arrived at Gondokoro from Entebbé the day before my own arrival. He told me that he had found *Glossina palpalis* to within 30 miles south of Gondokoro.

We arranged that he should proceed on the steamer allotted to him for that purpose down stream, and that later he should return and find me camping on the river bank. I was to go inland some miles from Gondokoro and see if I could find the fly away from the river, and then

proceed down it. Our respective investigations were made, but I later received a letter from him telling me that he had gone on to Khartoum without finding any "fly." My investigations yielded the same negative result, though much time was occupied in arriving at it. I had special permission from Brussels to investigate the bank of the Lado Enclave, but I received instructions to confine myself to the Sudan, so that I only investigated the right bank.

No "fly" found

I found no "fly" between Gondokoro and Shambé, although I was always on the look-out for it and had with me a Uganda boy who had been specially trained to catch "fly," and whose business it was to do so. It was only when I got to the Bahr-El-Ghazal country that I found *Glossina* of any species. It would appear that a river with vast swamps is not a suitable habitat, but that trees with water in proximity is what is preferred by these diptera.

During the above search I made expeditions in two directions from Gondokoro, and received great assistance from Capt. Tufnell, who saved me much expense.*

Bahr-El-Jebel. Trypanosomiasis

Capt. Greig left the Uganda boy above referred to at Gondokoro after trypanosomes had been demonstrated in the juice of his neck glands, and handed him on to me for treatment. I had brought up some chrysoidine on the chance of having this opportunity, as Dr. A. Balfour's experiments with this substance on mosquito larvæ and bilharzia ova already reported, had suggested to me that it might be useful in trypanosomiasis.

Injections of Chrysoidine

I at once began injecting chrysoidine hypodermically, giving $\frac{3}{20}$ths of a grain and increasing to half a grain when I found no untoward results. As this was probably the first time it had been used other than by the mouth, I had to proceed cautiously, but found that it appeared to be quite harmless to the patient.† While I went and came on the above expeditions, the boy had to remain at Gondokoro for treatment in respect to gonorrhœa and syphilis, and it was in consequence of Dr. C. J. Baker's kindness in continuing the injections of chrysoidine that I was enabled to carry out this experiment.

A fortnight after the first injection, on examination of gland juice, only one trypanosome was found after much searching. Many had been found previously. Subsequently Dr. Baker made several examinations and found none between this time and the end of January, when the boy was sent on to where I was camping on the Bahr-El-Jebel, at Luala's. Until the first week in March I remained on the river and injected the patient at first every day, but gradually diminished the dose to twice a week, and I often examined the gland juice without result. The boy rapidly improved from the first, got fat and only suffered occasional pangs from over-eating. I made a blood count in February, when the boy appeared quite well.

Blood Count

Lymphocytes	486
Large Mononuclears	61
Polynuclears	442
Eosinophiles	7
Myeloeytes...	4
	1,000

My march from Shambé to Meshra-El-Rek later on was rather a trying one, and the boy only got his injection about once in ten days.

* I have lately been informed that Dr. Hodges has found *Glossina palpalis* at Gondokoro further inland than I went.

† See, however, note on p. 162. (A.B.)

His work was hard and with less food his condition got lower, so that on arrival at Khartoum at the end of April I was disappointed when two trypanosomes (of an altered appearance, possibly due to devolution) were demonstrated in the gland juice. I at once began to inject him as before, and he again became fat and well. I heard of him as being in good health till July, but that a monkey injected from his blood shortly after his arrival had got trypanosomiasis. Dr. Balfour will, no doubt, report on his subsequent career.

Effect of Chrysoidine

It appears to me that chrysoidine in this case controlled the disease, at any rate, for a time, more easily than arsenic, trypanroth, etc.

Camps on Bahr-El-Jebel

After leaving Gondokoro I made five camps in all on the Bahr-El-Jebel, which, inclusive of 9 days moving from camp to camp absorbed 49 days from 14th January to 4th March, when I received urgent orders to visit the Bahr-El-Ghazal district. During this time I was chiefly engaged on the personal examination of bloods and the securing of blood films together with some work among the natives.

Examination of blood films

In all I made some 800 blood slides and it has been a matter of great labour examining them. While at work in camp the thermometer was often up to 110° F. and over in the tent. This, together with numberless flies attacking one's face and *Myzomyia* attacking one's legs, etc., made life unpleasant, especially when it is remembered that two hands are required when examining a blood slide under the microscope.

I also made a point of catching, examining and mounting mosquitoes and occasionally other insects. I had also to select and store the specimens, such as they were, brought in by the men. These, though not so numerous as could be desired, required much looking after. A few dissections were also made as well as a few birds skinned, but I soon found I had no time for the latter pursuits. As a means of collecting bloods of interest, photographs and other matters of value, I used to attend at 12 o'clock every day to see any patients from the neighbourhood. I regret to say that photographs were not successful as I had no time to work with plates, and my films were unfortunate.

It was asserted that I should be able to move up and down the river in the gyassas, but I found the first quite impossible as sails were of little use and it was only possible to drift with the stream, perhaps not making more than two miles or even less than that an hour. Consequently, I made use of the steamers to tow the gyassas as much as possible. Time was also occupied in going to see and in interviewing the various sheiks in respect of native drugs, customs, etc., and a little information and material was collected, but the Baris, among whom I was for the greater part of the time, are the most ignorant, negative race possible, living in idleness, taking no thought for the morrow, and enduring rather than taking trouble to fight against any difficulty that may arise. As a specimen of their most advanced ideas, I may mention a conversation I had with a sheik on the subject of the drought. He gave me the following information. There are bad spirits called "Geioch" and a god called "Dendi." The bad spirits are under the earth. Asked if God was one or many, he said he did not know, but his wise men knew. Men stop the coming of rain, being possessed of the bad spirits. Asked what would happen if these men were killed, he said the one that had done all the damage was at Coulin's; he had been in good health but after his imprecations could only go on all-fours and now could hardly move. At present he could do no harm. They were awaiting his death when all would be well. It was no use killing him,

Native beliefs

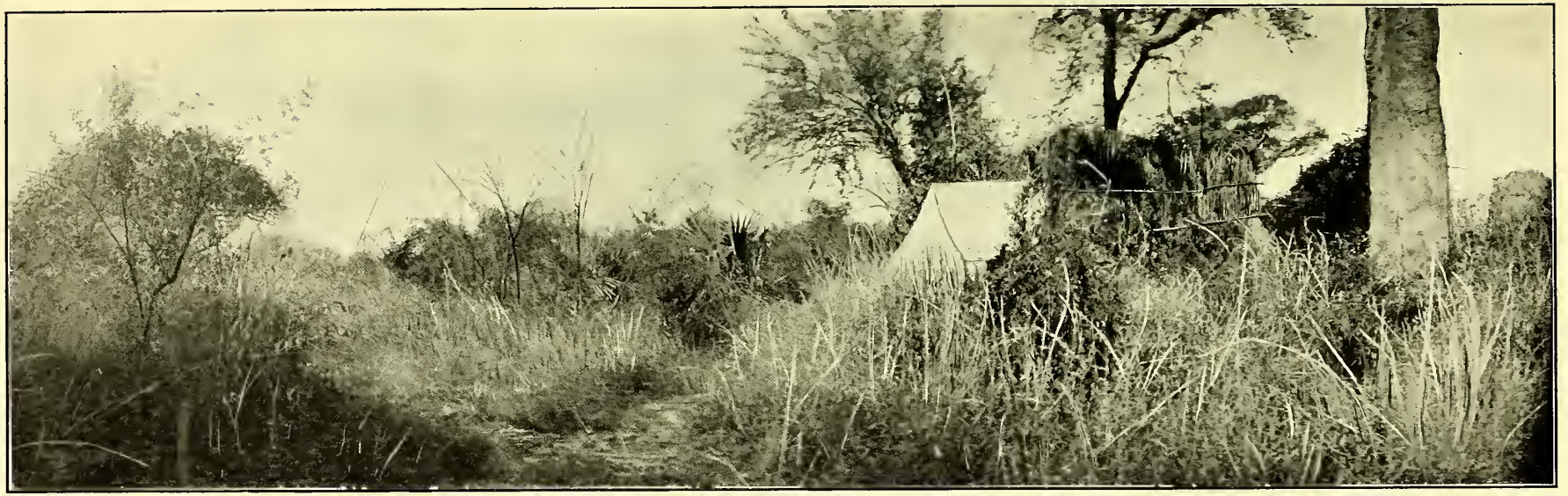


Fig. 84.—Camp at Luala's, showing "Surgery" Tent and Shelter

Fig. 85.—Camp at Luala's

Figs. 86 & 87.—Groups of Natives at Camp, near Akoor's Village, showing Emaciation owing to Famine

it would make matters worse, as he would then come back and do more damage in some other form. It appeared that this magician was considered to have suffered for his ill-doing at the hands of the good spirit. (Although the above answers do not always appear to be replies to my questions they are given as spoken.)

Everywhere throughout my sojourn on this river I found a famine of dura grain, the harvest having been a complete failure. The natives were much emaciated, especially the women. On remarking on the emaciation of his women to a Bari, he explained that the men went out hunting and fishing, but it was not the custom to bring home anything to the women, who were dependent on the grain; besides, "A man's belly is easily filled, but a woman's requires much." Famine of dura grain

Bahr-El-Ghazal

At Shambé I took, amongst others, the blood of seventeen cattle doing transport between this and Runbek, but neither then nor subsequently did I find any parasite in the peripheral

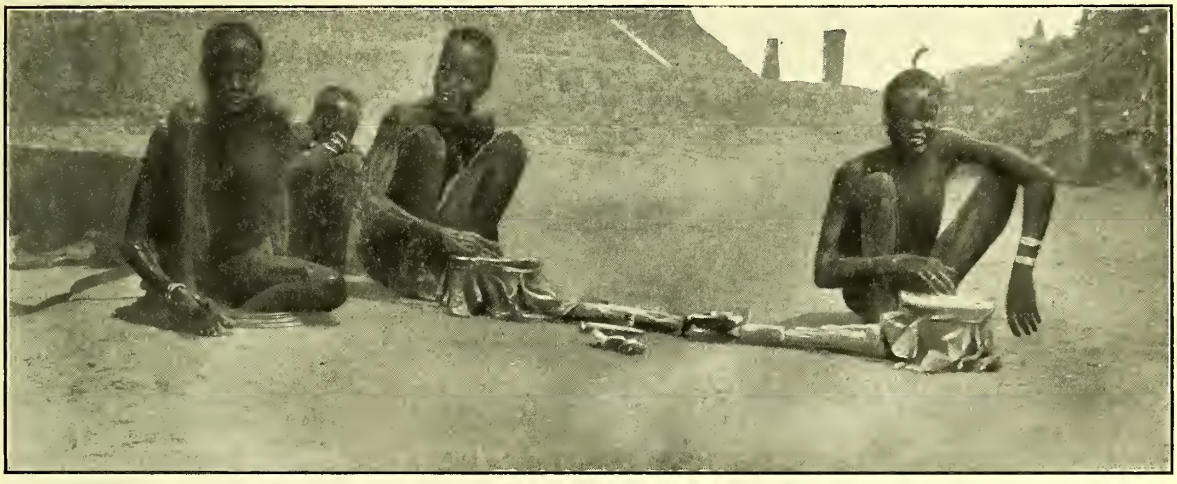


Fig. 88.—Native Brassfounder with Apparatus

blood in the transport cattle, but I was unfortunate in being unable to procure any with the disease at all advanced.

I saw here a native brassfounder making ingots for future use out of cartridge cases and other brass objects, and I eventually secured most of his apparatus for the Museum. His method was as follows: He had a hole in the ground and a basin-like crucible in it surrounded by charcoal. Also two bellows of earthenware, each worked by a small boy. These were of the following nature: a basin-like apparatus with a wide tube taking origin from the bottom of it at an angle, was covered with skin in the middle of which was a strip of hide which the boy pulled up and down. This caused an intermittent draught down the pipe, which was communicated to the bottom of the fire by another earthenware pipe or tuyere. The interval between these two pipes acted as a valve, causing the intermittent current of air to flow only towards the fire. I was surprised to find how easily he got enough heat to melt the brass. Native brassfounders

The ingot was about 5 inches long and about 1 inch thick, and was made by pouring the metal into a hole of the requisite shape in the ground. His pincers consisted of a piece of strong strap iron, as used for boxes, turned over double. The operator's hammers were pieces

of iron, round and pointed like a peg, and his anvils were hard pieces of stone. He had done well for himself, as, by making bracelets, he had acquired enough cattle to buy a wife.

The negotiation for purchase of his apparatus was a long one, and amongst other information he gave was a religious opinion far in advance of anything I had previously found. He thought the drought was due to the evil doing of men in the neighbourhood, and that the goodness of men like himself was not sufficient to produce the rain.

I left Shambé on 12th March, having received orders to locate the fly belts of the Bahr-El-Ghazal, take blood films and collect biting flies of all sorts. I had, however, to be some days at Meshra, to try and find some cattle likely to be suffering from piroplasmosis, and to start from there on 13th April. Thus I had only time to hurry through the country, and that I made the best use of my time is, I think, shown by the fact that I walked some 400 miles in twenty-seven days, including the distance from point to point. Results, however, were necessarily poor.

Bahr-El-Ghazal. Glossina

"Fly" found

I failed to find "fly" near Shambé, but had no time except to walk straight ahead. It was not until I reached Bahr-El-Gok that I found any. This was about 5 miles up the river from the station—undoubtedly *Morsitans* (*Glossina*)—though there appeared to be none actually close to the station. Here I secured the fly, Fig. 21, p. 56, which is the female of *Tabanus par*. I was informed that all the cattle died off here last year with what was thought to be lung disease of some sort. Here also I found the government convoy, and took the blood of the six draught cattle which looked well, but found no parasite.

This tallies to some extent with what the chiefs whom I questioned at Runbek told me. They said that there was a large fly between that place and Tonj, which did damage to cattle, and that all cattle died at Gok. They also volunteered the information that there was a cattle pestilence about 5 years ago, and that at the moment they were losing cattle, which they ascribed to intercommunication* of cattle between there and Tonj. As "fly" will accompany cattle a long way out of a fly-belt I should think their story may be correct.

They only eat their cattle when the latter die, as they are currency among them chiefly for wife-buying. This custom thus gives them opportunity for post-mortem examination, and they say they find the heart enlarged and full of clot, and a distended gall bladder. They also state that in life the animal suffers from cough and diarrhœa, with stools like water.

Native opinions

One of the sheiks had large patches of leucoderma on his hands, which he said was due to his having walked over his uncle's grave by mistake. This illustrates his ideas of the origin of diseases.

Before reaching Tonj, I slept the night about 5 miles from that station and secured another specimen of *Morsitans*. In the morning "fly" followed the caravan right into Tonj and into the rest-house. In the afternoon I wanted more specimens and sent out the Uganda boy to catch them, but they were not to be had. Next morning I made a long march down the river on the left bank but saw none. Eventually I had to march back to the camp where I had previously found them, before I could see any. This shows how they exist only

* The Government bullock waggon runs regularly between these places, I understand.

in patches, how they will follow a caravan but disappear again, and accounts for the discrepancies in the reports of different people as to the areas of fly-belts.

It also explains why flies have not been sent into Khartoum from Tonj itself. Further, it has been stated that in search for "fly" on a lake or river, all that is necessary is to land a boy, who can recognise them, for a couple of hours occasionally to catch a few; but these facts tend to show that a patch such as I have described might thus be easily missed, and also demonstrate that before declaring a country free of "fly" a very careful search would have to be made, which, in the case of the territory of the Bahr-El-Ghazal would take one man at least a couple of years.

In addition to the above, I found another patch about two hours march on the road to Wau from Tonj. Here (Tonj), the mamur told me the government cattle die at the rate of one a week, which, from the foregoing is easily explained, but unfortunately there were none sick at the moment for me to examine. From Tonj I determined to go straight to Meshra without going along the well-worn track to Wau, as I thought there was more chance of finding unknown patches of "fly" than if I travelled where many, capable of recognising the "fly," had probably been. The track, however, to Meshra, along which the government wells existed, was impossible owing to their being dry. Hence I had to go by byeways from sheik to sheik according to the information they gave me about water. Tonj to Wau

My path lay through the following places:

Police Station	General direction	N.
Village, Bilhega, Sheik Tonjan ..	,, ,,	N.E.
Aliat	,, ,,	N.E.
Cajungo, on Tonj River	,, ,,	N.
Temporary fishing camp	,, ,,	N.W.
Elwaitch	,, ,,	S.
Quaitch	,, ,,	E.
Akok	,, ,,	N.E.
Taba	,, ,,	N.
Teek	,, ,,	N.E.
Depeek	,, ,,	N.E.
Lan	,, ,,	N.E.
Meshra		

Thus my road was necessarily of a zig-zag character. During this part of the journey I met with no "fly," and passed through an immense alluvial area of very rich grass, affording forage for large herds of fine cattle. The latter had been collected from the high ground, which is at this time of year parched up. One evening while camping, I counted eight herds being driven in, averaging some 100 in each. The bulls, if fattened as in England, would turn the butcher's scale at from 85 to 95 stone. Even as it was, fed as they were on grass alone, there were some that would, I think, weigh out near those figures. There was a large population here living in the temporary villages engaged in tending the cattle and catching the fish in the pools which were gradually drying up. No doubt this part of the country is under water in the rains, and is probably quite free from "fly."

At this time of year the natives here dry a quantity of fish for future consumption, and from what I saw must eat a quantity of it half rotten, but I did not see a case of leprosy, though my hurried march did not give much opportunity for observation. On the other hand, I came across two cases at Luala's on the Bahr-El-Jebel. Figs. 89, 90 and 91. Leprosy

In addition to the above three patches of "fly" located by myself, I was told of the following localities as infected:—

Localities infected by "fly"

1. Nearly all the road from Wau to Tonj.
2. West bank of Jua Wau to Kojali.
3. Khor Dinji.
4. River Mongo, near Tambura.
5. 15 miles N. of Wau at Machioahli's.
6. A few miles out of Wau on road to Meshra.
7. Pongo River.
8. South of Tonj towards Minnobolo.

FIG. 89

FIG. 90

FIG. 91

LEPROSY OF HANDS

MESHRA TO KHARTOUM

Hippopotamus Hunt

My journey from Meshra to Khartoum was without special interest, except that I witnessed a hippopotamus hunt by natives, and as I have never seen their tactics reported it may be of sufficient interest to recount here.

I saw them first with a stout rope attached to a three-parts grown hippo., with some 50 to 100 men hauling on it, dragging him into shallow water. The rope broke and the beast got away, but he still had two spear heads trailing two ropes, with half-a-dozen large wooden floats attached. This *contretemps* gave me the opportunity of seeing how they put the noose on him again.

The hippo. was allowed to swim about for some time with the floats attached, and exhaust himself somewhat. His position was thus known, however long he might remain under and however little nose he might put out of water for breathing purposes.

After a time three men in a boat paddled up to him, and as he rose one of them in the bows tried to throw the noose over his head, but failed several times. The next time he rose this native jumped out of the boat with the noose held in the hands and with the arms wide apart, and tried, while in the act of jumping, to place it over the creature's head. He failed and scrambled back into the boat with marvellous rapidity. Nevertheless he made a second attempt and succeeded. The essence of the matter seemed to be to get the boat behind the head as it came up, and the man appeared to be safe while in the water behind it. If this surmise is correct, safety would probably lie in the animal not being able to make a sharp turn while swimming. However, I never saw a proceeding that appeared so foolhardy. The noose was drawn tight, and the other end attached to the cable-like rope in the boat, which was paid out till arrival at the shore, where the crowd seized it and gradually drew the animal into shallow water, where he received many spears and eventually succumbed. That the native sometimes gets the worst of it is shown by one whom I was called in to see, three days' journey the Meshra side of Tonj. He had a severe gash in the chest and had been awkwardly squeezed by the jaws of a hippo. To cure this his friends had made many gashes all over him, and he was in the most horribly septic state imaginable.

Native treatment

Antelope Blood-Serum

I had thought it would prove useful to investigate the action of the blood-serum of antelopes as a curative for trypanosomiasis, and in England had consulted various authorities as to the best way of extracting blood from a newly-killed animal so as to retain the serum aseptic. I also received much assistance at the rinderpest camp at Cairo. I had armed myself with an air-pump, some sterilised bottles into which to aspirate the blood and sterilised canulas to insert into a bloodvessel. All this was very bulky. I made several attempts, and after some practice succeeded in the case of three waterbuck in cutting down quickly on the jugular vein and getting a good quantity of blood. This was allowed to clot with the bottle in an inclined position and carried to camp. The next day the serum was drawn off into other sterilised bottles, and after having 4 per cent. of carbolic acid added to it was corked up.

Collection of serum

Of course, the difficulties were to carry all this apparatus about the place and have it at once on the spot after the victim had been stalked and shot, and then to prevent contamination.

Two or three dissections are sufficient practice to enable one to get down on the jugular quickly. The serum was forwarded to Khartoum, and Dr. Balfour, I understand, has made some interesting preliminary experiments.* I did not, however, get his letter asking for more serum until after I had left the boats and the apparatus to march across the Bahr-El-Ghazal, and was consequently unable to comply with his request.

I had hoped to take with me from Khartoum a donkey with trypanosomes in his blood, to make my own experiments with antelope serum, but the authorities considered it dangerous to import trypanosomes into a country which had not been investigated for tsetse fly. The above would form a subject for a special investigation which might lead to important results, as the destruction of domestic animals in the Sudan from this pest would appear to be very large indeed. No place of which I am aware gives so good an opportunity as the Sudan for thoroughly investigating these matters, the outside fringe of which has only been dealt with hitherto.

* See p. 166, *et seq.*

Technique of Blood Examinations

Slides were kept in pure lysol, and after a time carefully washed and placed in the boxes where they were to be stored when films had been made. Any dulling of the surface of the glass improved the film.

In the case of mammals it was comparatively easy to secure good blood films, but in that of birds, reptiles and fish, there was considerable difficulty. Unfortunately, owing to an error in the despatch of my outfit, I had to rely on my 12-bore with No. 8 shot only, and if a smallish bird was shot it was usually quite dead, and the cutting off the head on the spot yielded but little blood. At first I had a man carrying test tubes of citrate solution, but I found it very difficult to have him on the spot at the moment I ran to pick up the bird.

Later I hit on the plan of carrying three or four 3 inch by $\frac{1}{2}$ inch specimen tubes in the waistcoat pocket, which appeared quite satisfactory.

Methods of securing blood films

In addition, I always made one or two slides from the blood direct.

In the case of fish, after being held up by the tail to allow all water to drain out, the large artery supplying the gills was cut, or in the case of a small fish decapitation was performed.

Slides were always used for films to the exclusion of cover glasses, they give a larger area and necessitate much less time and care in making the film. They were all stained with Leishman's stain in troughs of the size of the slide, film downwards, thereby avoiding deposit. If any deposit occurs I find it easily removed by leaving the slide in xylol 30 minutes to 2 hours and then wiping gently with a small bunch of silk handkerchief and rinsing again in the trough.

Citrate appears to mix with the blood of birds and fish quite differently from that of mammals, making a glutinous mixture much more difficult to manipulate both in the centrifuge and in making films.

Before making any similar expeditions I hope to conduct experiments with a view to finding a better medium. I varied the strength of solution, but found none really satisfactory. On the other hand, on returning home, I found that slides that had been made a long time ago, and had endured a high temperature, stained much more easily in the case of birds and fish than in that of mammals.

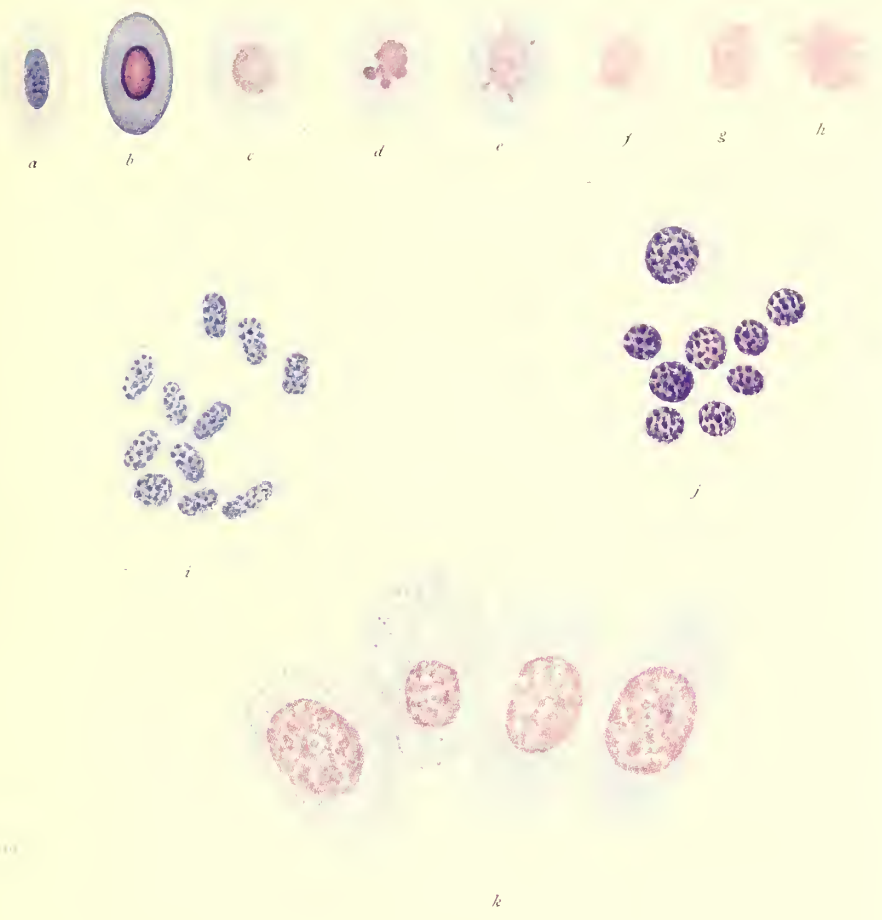
The system of making thick films and dehæmoglobinizing to detect extra-corpuscular parasites is not successful with bird or fish bloods, in consequence of the mass of nuclei which prevents anything being seen.

There is also a difficulty which seems to be due to the temperature at which one works. It is that when a film dries quickly the cytoplasm of the red corpuscles becomes often filled with little blisters, and this obfuscates anything else contained therein; so far, I have not found any way of avoiding this when films are made in the middle of the day.

The citrate difficulty also caused a difference in centrifugalising. I have been much disappointed in examining films for extra-corpuscular parasites that I knew should exhibit these, and that were made from the usual layer (*i.e.*, the layer just above the erythrocytes usually occupied by most of the leucocytes) for them in the case of mammal blood. I think there is no doubt that this layer differs in bird's blood, and owing to viscosity does not lie at the same level.

It is a matter of great regret to me that there was no time for systematic dissection, and the obtaining of the blood from the heart, etc., in a pure state, and the examination of

PLATE XVI



BLOOD OF VULTURE. DEGENERATIVE CHANGES IN ERYTHROCYTES, ETC.

(*a*) Normal.
(*b*) Chromatolysis of nucleus and chromatophilic degeneration of cytoplasm.
(*c*) Same as *b* together with alterations in shape of nucleus.
(*d*, *e and f*) Further stages of *c*.
(*g*, *h*) Free and altered nuclei.
(*i*) Immature erythroblasts.
(*j*) Lymphocytes?
(*k*) Endothelial cells.

Leishman Stain *All* × 1000 *diam.*

a series of hanging drops, nor for cultivation of trypanosomes and other such investigations. In consequence, most of my results are merely taken from stained blood films, which however, often included blood that had been allowed to stand in citrate for various periods with a view to detect development. This however, is a poor substitute for watching them on a warm stage.

I deplore the absence of further opportunity to verify and work out the indications many of these matters give.

Sources of Blood Collection

About 750 films were brought home in addition to those examined "in the fresh." These were made from the blood of:—

55 human subjects.	
118 other mammals,	16 varieties.
69 birds,	22 varieties.
33 fish,	8 varieties.
6 amphibia,	4 varieties.
18 sheep ticks.	

Normal Fish and Birds' Blood

The bloods of birds and fish have a number of peculiarities of their own, of which I have failed to find any description, so that I here note some of them.

Peculiarities of bloods of birds and fish

1. The red corpuscles appear to alter as soon as the blood is shed, that is to say, all slides show more or less the following phenomena. The majority of the erythrocytes stain in the ordinary way, exhibiting a violet blue nucleus, and if the Leishman stain has been well managed, a red cytoplasm, though the latter colour is often not easy to obtain in slides that have been kept for months at a high temperature. In fact, the cytoplasm not unfrequently remains blue unless special trouble is taken. A slide with the majority of erythrocytes wholly stained blue (as well as those with red stained cytoplasm), will show a number of other red corpuscles stained thus:—

1. The nucleus red, the stroma a very deep purple. (Plate XVI., b).
2. The nucleus red, the plasma lightly stained red. (Plate XVI., c). (Many of these are round with a round nucleus).
3. Many free nuclei swollen, stained red, and with ragged edges. (Plate XVI., g & h).

Again, the whole of the above process as far as the nucleus goes, may be carried on inside the corpuscle before bursting; and in this case after becoming reddened, and a kind of growth taking place, the nucleus continues to disintegrate until it is a ragged mass. All the above changes are shown in plate XVI., d to f, and are much exaggerated when the blood has stood for an hour or two mixed with citrate, the most extreme case showing nothing but these swollen and escaped nuclei. I consider that these changes occur in the blood between the time of its being shed and of its being made into a film. Endothelial cells from the capillaries are also fairly often seen in the films. (Plate XVI., k.)

Marabou stork's blood

In a slide of marabou stork's blood (containing *Halteridium*), I found some cells which are probably an early form of erythrocyte, either passed prematurely into peripheral blood or subsequently changed. The cytoplasm is contracted nearly up to the nucleus on each side, with a small vacuole at each end. The nucleus is swollen and flattened. Plate XVI., i.

There are also a number of deeply blue and purple stained objects, about 3·4 μ in diameter, often to be found in groups, which may be leucocytes or (as was suggested by Mr. Muir) who drew them) undeveloped erythrocytes. Plate XVI., j.

The polymorphonuclear corpuscles are remarkable for the variety of their granules. In Plate XVII. will be observed three varieties in shape, small round, ovoid and rod-like, together with transitional shapes between these two extremes. There is also a form with a round nucleus and granules of various sizes collected often to the periphery, these usually are basophile and stain a deep blue-purple though rarely they appear as eosinophile. Plate XVII., c.

A mast cell is represented at e.

There are lymphocytes of much the same appearance as those in human blood.

Lenses used

Contrary to the usual teaching, I find $\frac{1}{2}''$ object lens sufficient when searching for the trypanosomes in the blood of the averaged sized bird and fish, and $\frac{1}{4}''$ for trypanosomes and *Halteridium* in mammalian blood. This, of course, is a great saving of labour, but is only satisfactory when the observer knows exactly what he is looking for.

Summary of Parasites Found

Trypanosomes were found in the mule, four species of fish and two species of birds, as well as in the case of human trypanosomiasis already mentioned.

The blood of the shilbaia (*Schilbe mystus*, *Eutropius niloticus*) was frequently examined without success, and two specimens of the karesh fish (*Mormyrus*) with the same result.

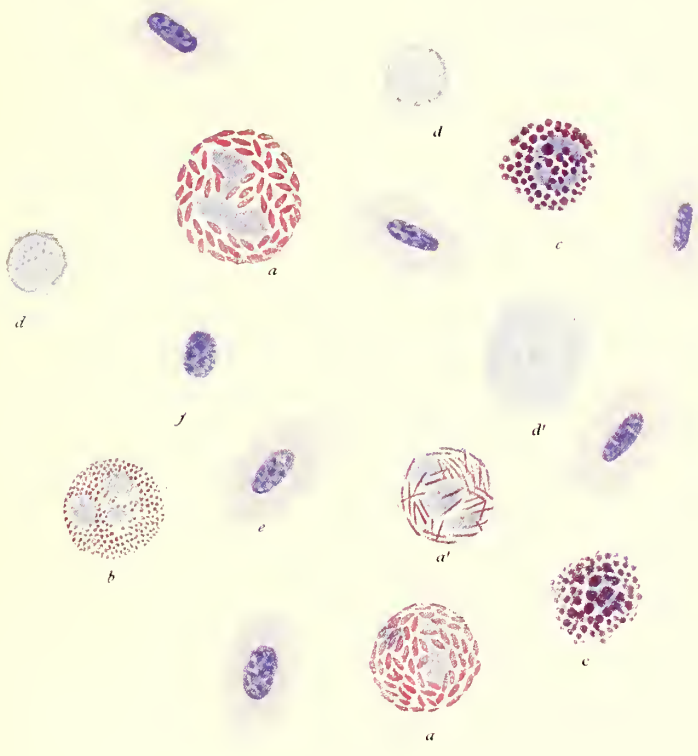
Parasites found

Filariæ were found in five species of birds, *Halteridium* in eight, and a new *Hæmamœba*, somewhat resembling *H. Ziemanni*, in one.

Halteridium	Filariæ	Trypanosomes	Protozöon	Hæmamœba
Wheatear (*Saxicola oenanthe*)	Guinea-fowl	Mule	Karesh fish (*Mormyrus*)	Guinea-fowl
Marabou Stork (*Leptoptilus crumeniferus*)	Vulture (*Neophron percnopterus*)	Bagara (*Bagcus bayard*)		
Kite (*Melvius ægyptus*)	Shrike (*Laniarius excubitorius*)	Gargur (*Lynodontis schal*)		
Red-breast Shrike (*Laniarius cruentus*)	Hornbill (*Lophoceros nasutus*)	Noke (*Mugil*)		
Red Hawk (*Accipiter rufiventris*)	Marabou Stork	Dabib (fresh only) (*Polypterus*)		
Brown Ibis (*Hagedashia hagedash*)		Red-breast Shrike (*Laniarius cruentus*)		
Koran (*Lissotis hartlandi*)		Vulture		
Guinea-fowl (*Numida ptilorhyncha*)				

The guinea-fowl (*Numida ptilorhyncha*) seems to be very liable to blood parasites, as in one slide I found *Halteridium*, an *Hæmamœba* and two types of *Filariæ*, as well as the object delineated in Plate XXI., b.c. The latter, I am informed by Mr. R. Muir who made these drawings, occurs in the corncrake in England, but I am unable to give any explanation of it, and merely append the drawing. Length varies from 50-58 μ and it occurs plentifully.

PLATE XVII



RICHARD MUIR

BLOOD OF VULTURE

a to *f* Various forms of Leucocyte.

Leishman Stain

× 1000 *diam.*

It would appear to consist of a sheath pointed at each end which contains protoplasm segmented into two or more portions.

In reference to the *Halteridium* found in this bird, the development of the parasite is but small, and the number of corpuscles affected scanty, and it has occurred to me that the appearance may after all not be *Halteridium* but the commencement of the growth of this *Hæmamœba*, though the simultaneous occurrence of *H. ziemanni* and *Halteridium* has been previously reported.

Trypanosomes

Plate XVIII. d. Trypanosomes found in the Noke (*Mugil*) fish, measure on an average:— Noke fish

Length, 50μ. Greatest breadth, 4μ.
Length of flag, 12μ
Nucleus, 4μ in diameter.
Centrosome, 5μ from end.
Corpuscles 12 to 13μ.

This fish has a gizzard and is a species of gray mullet.

Trypanosomes were found in the dabib (*Polypterus*) fish when examining the unstained blood on three occasions, but no stained specimen was secured. Dr. A. Laveran informed me that this was not an unusual occurrence* owing to the parasite being rolled up and hidden by the corpuscles.

Plate XVIII. a. The trypanosome found in the bagara fish (*Bagens bayard*) measures:— Bagara fish

Length, 51 to 58μ on an average. Greatest breadth 5μ.
Length of flagellum, 8μ.
Nucleus, 3μ in diameter.
Centrosome from end, ·2μ.
Corpuscles, 9 to 12μ × 5·5 to 6·5μ.

Plate XVIII. b. The trypanosomes found in the gargur fish (*Lynodontis schal*) measure on an average:— Gargur fish

Length, 24 to 43μ. Greatest breadth, 2·5μ × 4μ.
Length of flagellum, 8 to 10μ.
Nucleus, 2μ × 3μ.
Centrosome, from end, ·5μ.
Corpuscles, 11 to 12μ × 6 to 7μ.

Plate XXI. a. In the blood of the karesh fish (*Mormyrus*) a deeply stained organism was found, measuring 70μ in greatest diameter, and resembling some protozöon; (foraminifera?) It is nearly circular and its protoplasm arranged in a vortex-like depression, has a circle of cilia. It is probably a contamination from the gills, or the alimentary canal. The organism is plentiful, and from the way the fish was treated I think it highly unlikely that anything off the scales could have got into the blood. It is more likely a parasite of the gills and as trypanosomes have been found by scraping these with a spatula, it is worthy Karesh fish

* Since writing the above I find Novy and MeNeal report this as also their experience. They tell of a canary examined for 11 days in succession, when trypanosomes were found in the fresh blood and none in the stained and on its death 7 slide films were examined in vain for 20 hours, though the heart's blood revealed them in quantity.

of record, seeing that the life-history of trypanosomata is unknown. It will be remembered that Lingard has infected a horse by introducing trypanosomes into the alimentary canal, and it is difficult to see how fish can be otherwise infected.*

Mule

The trypanosomes found in the mule appear to be *T. dimorphum* both long and short forms being found, and a trypanosome resembling *T. nanum*. As these will be described by Dr. Balfour it is not necessary to give measurements, etc. The blood of 6 mules examined on board the steamer returning from Meshra-El-Rek from the war expedition all contained the above in more or less quantity. The blood of a mule examined just before death was crammed with them, four or five under the field of $\frac{1}{12}''$ object glass with No. 4 eye piece, being common. It was remarkable that many of the animals appeared to be in good condition.

Trypanosomes were found in two birds, viz., the common vulture of Egypt *(Neophron percnopterus)*, and the red-breasted shrike *(Laniarius cruentus)*; they appear to be exceedingly sparse in the peripheral blood of these avians, and there was no time to do more than examine this. Thus I only discovered two stained specimens in vultures, though I have examined a large number of slides from 10 different birds since my return. In the fresh, however, I saw them in 4 birds. In the red-breasted shrike I only found one specimen in three birds shot, and none in the fresh.

Vulture

Plate XVIII., e. and e^1. The vulture trypanosome *(Neophron percnopterus)* measures:

Length, 58 to 60μ. Greatest breadth, 4 to 5μ.
Length of flagellum, 10μ.
Distance, centrosome to end, 7μ.
Nucleus, $2\frac{1}{2} \times 4\mu$.
Corpuscles, 12 to $15\mu \times 5$ to 6μ.

The undulating membrane is only well marked in one of the two specimens found, and assumes the regular crinkled shape common to *Trypanosoma avium*. There is a vacuoloid appearance in both specimens; that in Plate XVIII. e. bulging the blunter posterior end, while that in f. does not alter the shape of the outline. It is V shaped with a small tongue of protoplasm projecting into the apex. The centrosome can only be seen in e^1. and that very indistinctly. In e. there is another spot (circular) unstained, rather nearer the anterior than the posterior end. The posterior end has a short flagellum 4μ in length.

The specimen e^1 tapers from both ends, and the posterior appears to have a flagellum as well as the anterior, some 6μ long. So different are these two organisms that it is a question whether they are identical. It will be noticed that these measurements are greater than those of the *Trypanosoma avium* previously described by others, but about the same as the larger form described by Novy and McNeal, in the article referred to above.

Red-breasted shrike

Plate XVIII. c. The red-breasted shrike *(Laniarius cruentus)* is a black bird with a red breast, about the size of the English blackbird. It lives in the thickest bush it can find, feeding on the ground below. Only one specimen of trypanosome was found, which measures:

Length, 28μ. Greatest breadth, 3μ.
Length of flagellum, 10μ.
Nucleus, 4μ.

* Sambon, however, has referred to flies feeding on Nile fish and Laveran has suggested the infection of fish by means of the lice parasitie upon them.—(A. B.)

PLATE XVIII

RICHARD MUIR

TRYPANOSOMES IN FISH AND BIRDS

(*a*) Trypanosome of *Bagara* fish (*Bagens bayard*).
(*b*) Trypanosome of *Gargur* fish (*Lynodontis schal*).
(*c*) Trypanosome of the red-breasted Shrike (*Laniarius cruentus*).
(*d*) Trypanosome of the *Noke* fish (*Mugil*).
(*e* and *e'*) Trypanosomes of the Vulture (*Neophron percnopterus*)
Leishman Stain

Centrosome, which is rod shaped, to end, 4μ.
Corpuscles, 10μ to 12μ × 6 to 7μ.

I am unable to identify this with any trypanosome already found.

Filariæ

The *Filariæ* here described are all embryos and were found after staining the blood for trypanosomes, the discovery of which was my main object in making these slides.

In *Lanius excubitorius* only I searched for the parent worm, having seen embryos in the fresh blood, but failed to find them.

None of the six embryos here described appear to have been previously found, though two of them somewhat resemble others mentioned below. It would appear that there are an enormous variety of unstudied *Filariæ* in birds in all climates.

Plate XIX., *b*. In several specimens of guinea-fowl blood (*Numida ptilorhyncha*) a *Filaria* was found in quantity, 80 to 100μ long, and 3·5μ broad, having the appearance of a disc necklace, or artificial serpent, as sold for a toy (Plate XIX., *b*), the granulations being arranged in disc-like sections which project on each side with great regularity. Guinea-fowl

These *Filariæ* are often arranged somewhat in a circle, and not as in the illustration (which was chosen as a specially fine specimen); they taper at the tail end to a fine extremity, while at the head the taper is much less, and the end bluntly rounded. There is a translucent spot at this end, and the stained cell nuclei finish in this spot in two divisions after bifurcation. There is no sheath, but there is a highly refractile translucent containing membrane. There are four spots, two of which only are constant. This *Filaria* much resembles the description of *F. calabarensis* in the report of the expedition to Nigeria by the Liverpool School of Medicine, except for the regularity of the granulation.

Spot 1, at 24·3	per cent. of length	Often absent.
Spot 2, at 33·4	,,	Constant.
Spot 3, at 59·3	,,	Constant.
Spot 4, at 80·5	,,	Often absent.

Plate XIX., *a*. Another *Filaria* in the same slides has the tail end tapered and pointed, while the head end is slightly tapered but bluntly rounded. It has a sheath nearly double the length of the filaria. In the stained specimen the head is pushed to the furthest extremity of the sheath, the excess of which trails behind. The sheath stains a deep red colour, making the protoplasm within look purple. As a rule the *Filaria* lies fairly straight, without much undulation. It has a containing membrane, the contents of which appear to be segmented at the tail end and granular at the head end.

The length is from 48 to 85 μ by 3·8 μ. There are five spots of which three are constant. At the head end there are two clear spaces, the more anterior of which is at the extreme end, communicating with the other by a narrow channel between two sides formed by the splitting of the mass of the cell nuclei. This is probably an embryo which has not been previously described.

Spot 1, at 11·2	per cent. of length	Often absent.
Spot 2, at 34·1	,,	Constant.
Spot 3, at 53·9	,,	Constant.
Spot 4, at 77·3	,,	Constant.
Spot 5, at 90·5	,,	Often absent.

Vulture

Plate XIX., *c*. In the common vulture (*Neophron percnopterus*) a single filaria was found in the blood, also of the disc necklace variety, though this arrangement of granulation is not so well marked. It measures 120 μ by 3·2 μ in breadth. The illustration shows two curious large hyaline structures at about the middle of the parasite, which would apparently distinguish it from any described variety, but it is unsatisfactory to make deductions from one specimen. In another bird a single specimen (160 μ in length) of some *Filariæ* was found, but too much buried in corpuscles to describe.

Shrike

Plate XIX., *c*. In the shrike (*Lanius excubitorius*) a *Filaria* is found, 75 to 205 μ long, with blunt ends, and about 3 to 4 μ at broadest part. It takes the stain very badly, with a rather hyaline appearance, but is slightly granular. Especially granular areas occur around two spots, which are fairly constant, at 30·3% and 60·7% of its length. Other spots sometimes occur but not at regular intervals. From its outline it would appear to have a containing membrane, but no sheath.

A *Filaria* was four times seen in fresh specimens of this blood, which differed from the above in being about 200μ long, and 5μ broad, having one end of a pointed shape with a shoulder, while the other end tapered somewhat. Unfortunately no stained specimen was obtained although 31 slides in all of the blood of this species was examined. Movements were both wriggling on its own ground and advancing across the field. There was a V spot near the middle, with granules posterior to this.

Hornbill

Plate XIX., *d*. Only one specimen of the hornbill (*Lophoceros nasutus*) was shot, and in the blood was found a *Filaria*, 65 to 105μ long and 3μ wide, with one pointed and one round end, and with disc-like granulations but no sign of sheath. This is probably identical with that found in *Numida ptilorhyncha*.

Marabou stork

Plate XIX., *f*. In the marabou stork (*Leptoptilus crumeniferus*) a *Filaria* was found 70 to 104μ by 3μ, taking the stain badly and faintly granulated, round at the head end and pointed at the tail. The granulations divide at the head end and terminate in a bay leaving a portion unstained. There are three spots all constant. There is a hyaline containing membrane.

The first spot at 26·63 % of length consisting of a transverse bar.

The second at 38·71 % of the length.

The third at 60·14 % of the length.

This somewhat resembles an embryo *Filaria* found by Dr. G. C. Low in the Java sparrow which he has kindly shown to me.

New Hæmamœba

Plate XX. An *Hæmamœba* was found in the blood of the guinea-fowl (*Numida ptilorhyncha*) which somewhat resembles *H. ziemanni*. There are two varieties probably

Description

(as in *Halteridium*), male and female, the former hardly taking the stain, while the latter takes on a very deep blue colour (even when the blood elements generally are so lightly stained as to hardly exhibit any colour) and shows itself to be markedly granular. There are in some cases two more transparent portions, one on each side of the centre of the parasite, which in the male especially are dotted with chromatin spots. The parasite is from 15 to 20μ long and about 5μ broad, in addition to which the ends of the corpuscle are drawn out, each sometimes being as much as 10μ in length. The female parasite as it grows, wholly alters the shape of the corpuscle, pushing the nucleus of the corpuscle on one side, while the

PLATE XIX

FILARIÆ IN BIRDS

(*a*) In the Guinea-fowl (*Numida ptilorhyncha*).
(*b*) Another species in the Guinea-fowl.
(*c*) In the Vulture (*Neophron percnopterus*).
(*d*) In the Tree-Hornbill (*Lophoceros nasutus*).
(*e*) In the Shrike (*Lanius Excubitarius*).
(*f*) In the Marabou Stork (*Leptoptilus crumeniferus*).

Leishman Stain *All* × 1000 *diam.*

ends of the *containing membrane of the corpuscle are drawn out to the finest filament, so fine in some instances that a flagellar-like appearance is caused. The contents of the corpuscle appear to be under great pressure. At first the whole is crescent-shaped and uniform in outline, later the pressure against the nucleus creates a lobe in the middle, with an expanded portion bulging on either side; beyond these again are the drawn out ends and flagellar-like terminations of the corpuscle. So close does the parasite lie against the corpuscular nucleus that it cannot be distinguished as a separate entity. The nucleus of the parasite presents some difficulty. In some cases it appears as if flattened and pushed hard against that of the corpuscle, the line of demarcation being difficult to detect; in others the staining is so similar to the rest of the parasite that the outline is difficult to detect.

In several instances, two of which are illustrated in Plate XX., the parasite is seen pushing a portion of itself through the containing membrane of the corpuscle, and appearing as a globular hernia.

In one of these the corpuscular nucleus is also being extruded, and appears to the eye as if included in the parasite; in another, the globule is found at the opposite side, and again, in other specimens, the extruded globule is seen arising from either end of the parasite. It is possible that this is the commencement of the globular form described by M. Laveran in the case of *Ziemanni*, or the process might be one of ordinary fission, or even perhaps a pathological state induced by shedding of the blood and spreading it out as a film, though I do not think the latter likely.

It is to be noted that Laveran and Lucet (L'Academie de Sciences, 30th Oct., 1905) speak of the nucleus being expelled from the corpuscle by *Hæmamœba relicta*.†

Long narrow form

There is a long narrow form, Plate XX., *c*., without any visible nucleus, corpuscular or otherwise, which may be the parasite after parting with one of these globules.

It will be remembered that Schaudinn has stated that this parasite has a trypanosomatic stage (as well as *Halteridium*), and that in that form it attaches itself by its posterior end to an erythrocyte which it then draws into itself. He asserts also that after it has digested the plasma the nucleus is pushed off to one side as an elongated halter-shaped body, eventually to be thrown away as waste. This however, is combated by Novy and McNeal,‡ who show that trypanosomes are very common in birds, and believe that the occurrence of the two parasites in one blood is fortuitous (viz. *H. ziemanni* and trypanosomes). Although my specimens tend to show that the parasite is endo-corpuscular, yet it is hard to explain why the ends of the containing membrane of the corpuscle should be drawn out to fine points, even resembling flagella. The suggested passage through a capillary is an insufficient explanation.

The description by §Laveran and his illustrations, as well as those of ‖Schaudinn, show in the case of *Ziemanni* the nucleus of the corpuscle flattened out, being elongated to at least four times its normal length, so that the ends surround the parasite; in the case of my films, the parasite surrounds one side and both ends of the corpuscular nucleus, projecting in most cases beyond it at each end to an extent equal to the length of the flattened nucleus.

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* "Containing membrane" is a term only used for the purpose of description, though those who argue that such a membrane does not exist should examine this class of specimen.

† Since writing the above I have found specimens with the globule just freed from the element. Plate XX.

‡ Novy and McNeal. Journal of Infectious Diseases. Chicago, 1st March 1905.

§ Soc. de Biol., 16th May, 1903.

‖ Arbeiten aus dem Kaiserlichen Gesundheitamte, Band XX., Heft 3, 1904.

It would appear therefore, that this parasite is not identical with *H. Ziemanni*, but is a new species. Dr. Laveran has kindly examined it and considers that I may safely treat it as such. Dr. Balfour has suggested that it be provisionally named *H. Neavei.*

Mammalian Blood

The investigations made in respect of mammalian blood yielded negative results, except in the case of malaria in man, and trypanosomes in the mules from the war expedition.

Human blood

Man.—No extracorpuscular parasites were found with the exception of the trypanosomes already mentioned in the Uganda boy. Nearly all the children's blood examined, contained a few tertian malaria parasites, and these were also present in a few of the adults. At the hospital in Taufikia the blood of six soldiers was taken, in which the typical tertian parasite was found, and one with both tertian and quartan.

All the men, except myself, in my expedition, were down from time to time with malaria, but answered at once to quinine treatment.

Blood of wild mammals

I examined a large number of slides of blood from the antelopes and other wild mammals that existed on my line of march, but found no parasites in the peripheral blood, either in the regions of the *Glossina morsitans*, or elsewhere. I strongly suspect that the main reservoir of nagana exists in the young of these animals, exactly as malaria does in the young of the human being.* It is reasonable, I think, to suppose that the infection takes place early, and that the adult attains a large measure of immunity thereby. It is unlikely, but possible, that young calves might have more resistance than older cattle and might acquire an immunity in the same way. An experiment with a few young calves, donkeys, etc., might easily be made in Khartoum.

Amongst the animals examined were:—

Kongoni.	Oribi.	Dog.	Water Buck
Bush Buck.	Rat.	Sheep.	Ox.
Hippopotamus	Donkey	Mule.	Tiang.
Goat.	Reil.	Wild Pig	Wart Hog.

Insects

A collection was made, but not in the quantity I had hoped, in consequence of my having to attend to blood work, and being unable to make the natives collect.

This collection was more than half destroyed in its transit to England, but there still remains a residue of which I hope to render an account in time for the next 'Laboratories' Report. I hope also, to include details as to a private collection I made the year before.

Diptera

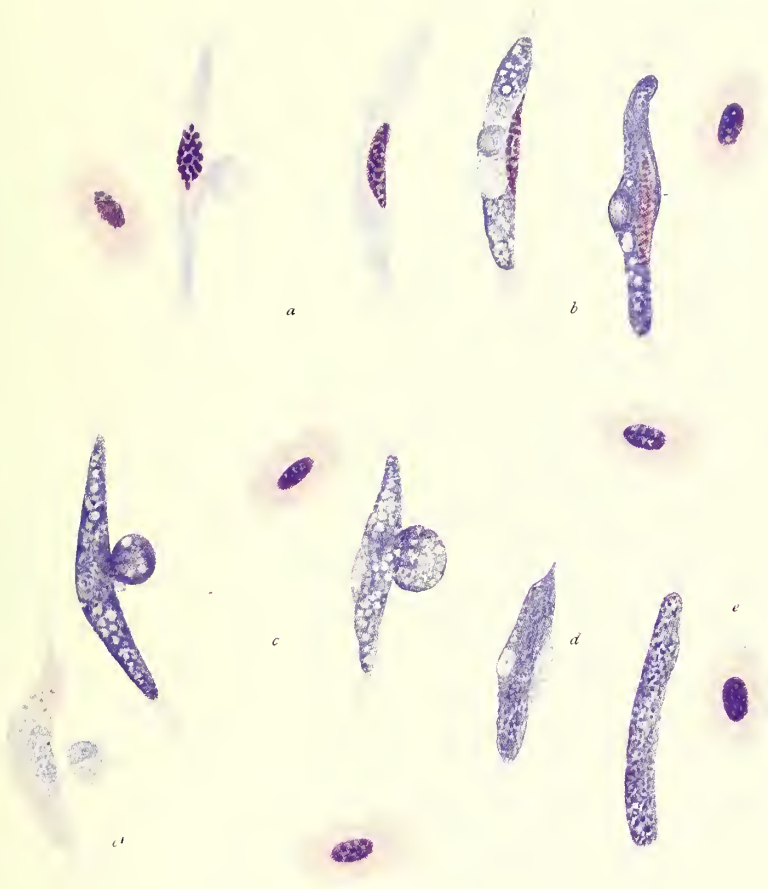
Specimens secured

The following Diptera in good condition were secured. Although a few others were obtained they were much damaged in their transit to England, and are useless for description:—

1. *Tabanus dorsivitta* or *virgatus* (Austen).
2. *Tabanus par.*

* Koch has again drawn attention to the paucity of trypanosomes in the blood of infected big game, and quite recently has suggested that a special developmental form adapted for the tsetse fly may yet be found in antelopes or buffaloes.—(A. B.)

PLATE XX



RICHARD MUIR

HÆMAMŒBA OF THE GUINEA-FOWL (*H. Noæveï*)

(*a*) Male parasite. (*b*) Female parasite. (*c*, *c'*, *d and e*) Various stages of division.

Leishman Stain *All* × 1000 *diam.*

3. *Chrysops distinctipennis.*
4. *Dryxo.* A species also known in Uganda, but not yet named.
5. *Auchmeromyia luteola;* Fabr. The Congo floor maggot fly.

Mr. Austen of the British Museum kindly named these for me (*Vide* pp. 53, 56, 60 and 86).

Mosquitoes

While camping I caught a large quantity, but there was hardly anything else among them than *Mansonia uniformis* and *Myzomyia funesta*, together with a few *Cellia pharœnsis*, *Tœniorhynchus tenax* and *Pyretophorus costalis.*

While on the steamer, however, I secured a number of males. The weather was unusually cool, and the sterner sex was much more in evidence than the female. They were referred to Mr. F. V. Theobald who has included them in his report. The most interesting appear to be two new obscure *Culex** and the male of *Myzomyia nili*, which had not been previously captured. I have now made several journeys on the steamboats on the Bahr-El-Jebel and find that for variety they are far the best place for collecting mosquitoes as one seems to tap new tribes from night to night. This ought to give a good opportunity for the laboratory collection.

New species

Plants

A very small collection was made, and of these only three have reached me. They were all used for medical purposes among the Bari as infusions. One village, however, would use them for one disease, while in the next, one found the same plant being used for another purpose. Professor E. M. Holmes, of the Pharmaceutical Society, has kindly promised to give me some information about them, which I hope to detail later.

Native medicinal infusions

Medicine, Surgery, Anthropometry

I have little of interest to report, as the native was, as I have said above, unwilling to submit to any prolonged treatment. At the same time I kept a journal of these matters, and hoped on studying it to have been able to make some remarks of more or less interest. It has, however, never reached me in England, and I fear, has been lost.

From memory I may say that I found tubercle to be rife among the natives wherever I went, and all the lung complaints common in Europe. Lesions, which in England would be attributed to syphilis, are also very prevalent. I saw lymph scrotum, cases of acute rheumatism, actinomycosis and leprosy. Hydrocele was one of the commonest diseases I was called on to treat.

Common diseases

In matters surgical there were many things of interest, chiefly due to the non-treatment of injuries, etc., and their arriving at a stage which is never permitted in civilised parts.

I saw a female of about twenty-five years with an enormous umbilical hernia quite as big as a full-sized football, containing the greater part of the intestines. I met her carrying a load on her head quite comfortably. She said it was congenital, that it did not incommode her, and would not hear of any treatment, even if it were possible.

There is a wide field for the study of disease among these natives, large numbers of whom are treated at the hospitals attached to the military, and other posts on the river.

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* Named by Mr. Theobald *Culex rubinotus* and *Culex neavei*

It strikes one at once how much might be learnt if only by the study of the blood in the diseases of these men, about whose habits of life it is not difficult to acquire information.

I still hope to recover the above journal in which I recorded measurements of a good many natives on the Bahr-El-Jebel.

Anthropometry

What strikes the eye is the length of leg in comparison to that of the trunk, and a very narrow pelvis, observations which the measurements seemed to confirm to some extent.

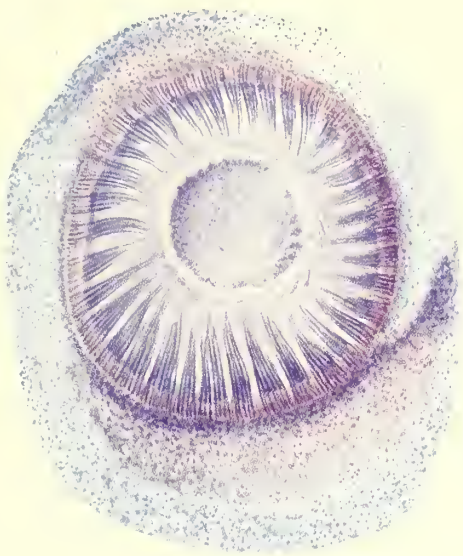
The children up to sixteen years of age, especially the females, have a marked lordosis in excess of the white races, suggesting that the erect attitude was attained at a later period by them than by us.

Conclusion

In conclusion I have to tender my thanks for all the courtesy and help I received at the hands of those I met both at Khartoum and up country, which did much to relieve the many disappointments and difficulties encountered in my endeavour to achieve some success in this expedition.

As in many expeditions I have previously made I return with the feeling that had I better known the country and circumstances, I could have done twice the work at half the expense.

PLATE XXI



a

b *c*

RICHTER MUNICH

UNKNOWN AND PECULIAR BODIES IN FISH AND BIRD BLOODS

(*a*) In the *Karesh* fish (*Mormyrus*). Ciliated organism possibly from the gills.
(*b and c*) In the Guinea-fowl (*Numida ptilorhyncha*).

Leishman Stain *All* × 1000 *diam.*

REPORT

OF THE

CHEMICAL SECTION

OF THE

WELLCOME RESEARCH LABORATORIES,

GORDON COLLEGE, KHARTOUM

BY

WILLIAM BEAM, M.A., M.D., F.I.C., F.C.S.

Summary of Analyses

The following is a summary of the analyses and examinations undertaken in the Chemical Laboratory from October, 1904, to the 15th of November, 1905:—

River Waters	42
Well Waters	15
Grains	20
Milks	18
Dried and Condensed Milks	6
Oils and Fats	4
Beverages	3
Salt	6
Gums	14
Drugs, etc.	9
Rubber	3
Urine	4
Calculus	1
Arrow Poison	1
Soils	4
Fertilizers	2
Lime	7
Limestones	21
Other Minerals and Ores	24
Miscellaneous	3
Total	207

In many cases the examinations were not carried as far as was desirable, not only because of single-handedness * in the laboratory but especially on account of the want of special chemicals and apparatus, and of the long time which had to expire (three to four months) before material ordered from England or the Continent could be received. Another source of vexation was the continual failure of gas and water supply. Much of the work had to be repeated, in some cases several times, because of this and of the overwhelming effects of sudden sand-storms. Fortunately the latter are not common except in the Spring and Summer months, and as the water and gas supply are now both more constant, it is hoped that the intense annoyances of the past will not be repeated.

Disadvantages of acetylene for laboratory use

It might not be amiss here to sound a note of warning to those who may have to undertake the construction of laboratories in out-of-the-way places like the present. The acetylene gas system, while so attractively simple, has, apart from the question of cost of carbide, several disadvantages. It was found that the flame of the acetylene bunsen is so hot that breakage of glassware was a very considerable item. This may often be avoided by the use of sand-baths or hot plates, or by the interposition of two pieces of wire gauze, in place of a single piece, between the glass vessel and the flame. All this entails a waste of heat.

Effect of acetylene on platinum

A more serious objection is the effect on platinum ware. After exposure to the flame, the surface of the platinum becomes of a scaly crystalline appearance; the metal becomes hard and brittle and ultimately cracks. If used in conjunction with a blast the flame is so hot that the metal, if thin, may even be melted.

Our present system is to employ the spirit (alcohol) bunsen for platinum vessels and the acetylene gas for other purposes. This is not entirely satisfactory, as alkaline fusions of silicates are difficult by such means.† Later it is hoped that funds may be available for the installation of a proper gas system of the ordinary pattern.

Chemical Composition of the Nile Waters

A series of examinations of the waters of the Blue and the White Nile was undertaken with a view more especially to determine the comparative amounts of suspended matter carried at different seasons of the year. During my absence in Europe my instructions in regard to the collection of samples were not carried out, and no determinations were made for the month of September, except of a single sample of the White Nile water collected independently by the Department of Irrigation. The lack of examination of the Blue Nile during this month is greatly to be regretted, but it is hoped that it will be possible to make a more complete series of observations this year.

The samples from the White Nile were taken from a point about two miles above the junction with the Blue Nile. Those of the Blue Nile were taken opposite the far end of Burre—about a mile beyond the built-up portion of Khartoum, and about three miles from the junction of the two rivers. In future the samples from the White Nile, especially during the flood, will, if possible, be taken from a point sufficiently far up the river to avoid the disturbing influence of the Blue Nile water.

The figures, which are in many cases the mean of several determinations during the month, express parts per million.

* This was written before the appointment of Mr. Goodson as Assistant Chemist.

† Since the above was written fusions have been effected by means of benzine and an ordinary blast-lamp The apparatus extemporized for the purpose is figured and described on page 244.

White Nile

	1904		1905										
	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.
Solids in suspension	82·75	74·02	70·84	67·00	55·00	56·19	52·20	49·00	75·7*	142·6*	26·5	32·00	44·00
Solids in solution...	165·00	162·70	160·00	...	177·50	...	196·00	199·00	...	...	...	140·00	142·00
"Free Ammonia" (NH_3) ...	0·020	0·012	0·020	...	0·020	...	0·024	0·023	...	...	...	0·016	0·019
"Albuminoid Ammonia" (NH_3)	0·240	0·272	0·340	...	0·230	...	0·260	0·300	...	...	...	0·260	0·284
Oxygen absorbed in 10 minutes, at 100° C.	n. d.	6·76	6·15	...	8·53	...	8·00	8·70	...	...	...	6·00	6·40
Nitrites (N)	none	none	none	...	none	...	none	none	...	...	...	none	none
Nitrates (N)	0·085	0·070	0·095	...	0·091	...	0·098	0·089	...	...	...	0·078	0·089
Carbonates (CO_3)...	49·92	51·00	57·60	...	85·80	...	90·48	94·00	...	...	...	54·23	54·80
Chlorides (Cl)	4·80	4·55	5·39	...	9·15	...	11·41	11·50	...	...	...	5·58	5·58
Sulphates (SO_4)	none	none	none	...	0·95	..	1·00	1·22	...	...	...	none	none

Blue Nile

	1904		1905										
	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.
Solids in suspension	57·59	19·42	6·61	4·00	8·95	6·5	7·0	7·0	472·0*	993·5*	...	110·0	66·0
Solids in solution...	105·00	109·15	115·00	...	120·00	...	130·00	135·00	...	...	...	110·0	103·00
"Free ammonia" (NH_3) ...	0·010	trace	0·006	...	0·020	...	0·030	0·032	...	...	...	·018	0·015
"Albuminoid ammonia" (NH_3)	0·140	0·114	0·075	...	0·160	...	0·180	0·198	...	...	...	0·169	0·138
Oxygen absorbed in 10 minutes, at 100° C.	n. d.	1·70	0·80	...	0·65	...	0·84	0·89	...	...	...	3·65	2·20
Nitrites (N)	none	none	none	...	none	...	none	none	...	...	...	none	none
Nitrates (N)	0·030	0·022	0·015	...	0·029	...	0·050	0·054	...	..	...	0·040	0·035
Carbonates (CO_3)	40·84	41·40	47·45	...	55·80	...	57·09	59·89	...	...	...	44·52	40·28
Chlorides (Cl)	1·64	1·56	1·50	. .	2·68	...	4·51	7·70	...	...	. .	2·64	1·86
Sulphates (SO_4)	4·95	5·10	7·00	...	7·23	...	7·60	7·69	...	...	...	4·97	4·80

* Determination made by H. R. Friedrichs

More complete examinations were made on the following dates :—

	WHITE NILE			BLUE NILE		
	Dec. 20th, 1904	Jan. 12th, 1905	June 4th, 1905	Dec. 20th, 1904	Jan. 12th, 1905	June 4th, 1905
Solids in suspension	65·00	74·00	49·00	16·50	6·00	7·00
Solids in solution	165·40	160·00	198·00	110·00	115·00	165·00
"Free Ammonia" (NH_3)	·015	·020	·023	trace	·006	·032
"Albuminoid" (NH_3)	·280	·340	·300	·098	·075	·198
Oxygen absorbed at 100° C. in 10 minutes ...	6·55	6·15	8·70	1·40	0·80	0·89
Nitrites (N)	none	none	none	none	none	none
Nitrates (N)	·085	·095	·089	·020	·015	·054
Chlorides (Cl)	4·90	5·39	11·50	1·65	1·50	4·70
Carbonates (CO_3)	52·80	57·60	94·00	42·00	47·45	59·89
Sulphates (SO_4)	none	none	1·22	5·40	7·00	7·69
Calcium (Ca)	12·30	13·20	20·96	18·40	21·81	25·53
Magnesium (Mg)	3·81	3·98	6·49	4·37	4·65	5·89
Sodium (Na)	22·70	23·40	36·89	5·57	6·01	7·81
Potassium (K)	9·14	8·90	14·27	1·40	1·52	1·90
Silica ($Si O_2$)	24·00	25·00	21·00	26·00	24·00	23·50

The proportion of CO_3 recorded represents simply the measure of the alkalinity determined by direct titration with acid.

Suspended matter in Nile waters

Solid matter in suspension.—For more ready comparison, these figures have been tabulated separately as follows :—

	WHITE NILE	BLUE NILE
November, 1904	82·7	57·6
December „	74·0	19·4
January, 1905	70·8	6·6
February „	67·0	4·1
March „	55·0	8·9
April „	56·2	6·5
May „	52·2	7·0
June „	49·0	7·0
July „	75·7	472·0
August „	142·6	993·5
September „	26·5	not det.
October „	32·0	110·0
November „	44·0	66·0

For the greater portion of the year the White Nile carried from 50 to 80 parts of suspended matter per million. In August it rose to 142 parts, but this may have been derived in part from the Blue Nile, the flood of which is so much greater that in July, August and September it may actually flow up the bed of the White Nile for a short distance.

During the period of flood of the Blue Nile, the pent-up water of the White, which has a very slight slope (only 1 in 100,000 in flood) forms an immense lake or storage reservoir. The effect of the slowing up of the current is apparently seen in the proportion of suspended matter in September and October, when the figures drop to 23·5 and 32·0 respectively. The grosser particles have settled, and there is present chiefly the finer clayey matter.

The White Nile was thus never found free from an appreciable amount of suspended matter. The Blue Nile, on the contrary, although carrying in flood an enormous amount of mud, later, from January till June, becomes almost clear. The contrast between the two rivers in this respect is best shown by the following diagram, in which is charted, as well, the flood of the Blue Nile from readings of the river levels taken daily by the Department of Works. The figures represent these levels and not the actual volumes of water discharged, but will suffice for the present comparison.

CHART SHEWING RELATION OF FLOOD TO THE EXTENT OF SUSPENDED MATTER CARRIED BY BLUE AND WHITE NILE RIVERS NEAR KHARTOUM

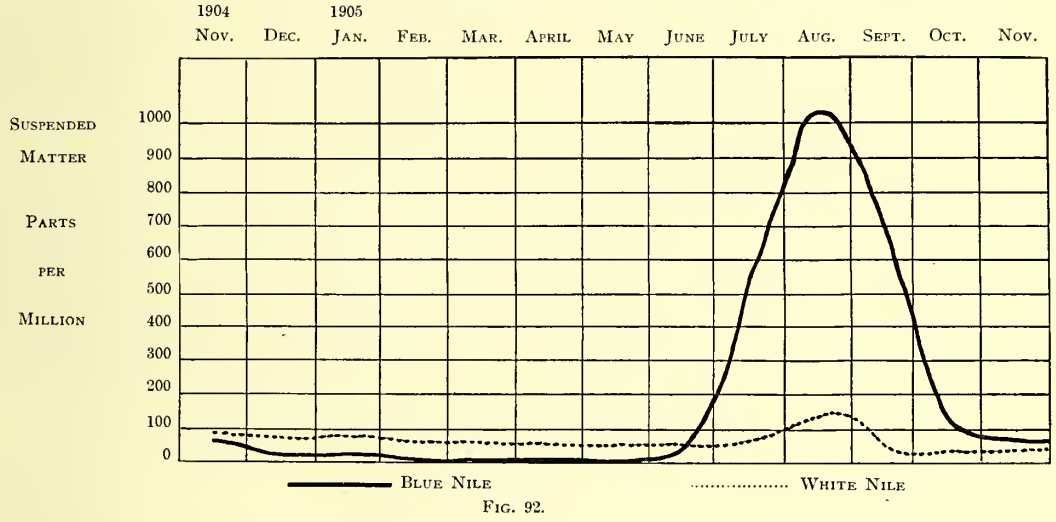


FIG. 92.

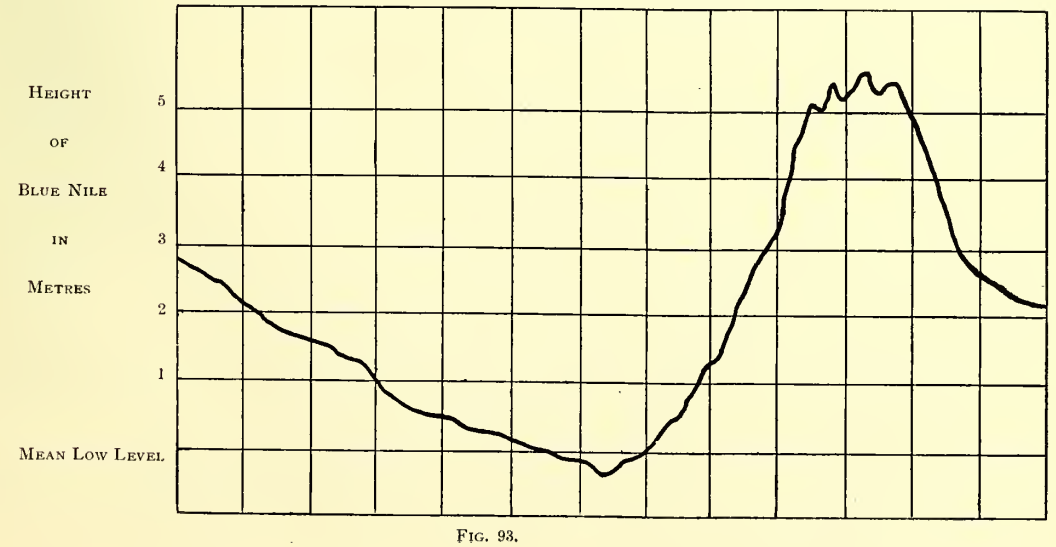


FIG. 93.

While practically clear during the months mentioned above, the Blue Nile water was never found absolutely free from suspended matter. The highest proportion found was on August 12th, 1,166 parts per million, and the lowest on January 12th, 4 parts per million. When nearly clear, the suspended matter was not clay, as in the case of the White Nile, but coarser particles, probably sand and other material blown into the river by the high winds which prevail during the winter and spring months.

Colour of "Blue" and "White" Nile waters

The colour of the "Blue" and the "White" Nile water.—It has been mentioned that the White Nile water, while it carries a comparatively small amount of suspended matter, is never clear. The material in suspension is in great part very fine clay, and, especially after the larger particles have settled, the water when examined in a glass vessel has a slight milky-white colour or opalescence. This clay remains in suspension a very long time; samples which remained undisturbed in the laboratory for weeks were still distinctly opalescent. The Blue Nile water, on the contrary, especially in the season of lower water (from January till June) is comparatively—for the greater portion of the time, almost quite—clear, and like other clear water containing little organic matter, has a blue colour when viewed in deep layer.

The reason for the different behaviour of the two waters becomes apparent by reference to their composition. The White Nile water contains but a very small amount of calcium and magnesium compounds, and a comparatively large amount of sodium and potassium carbonates and bi-carbonates. Blue Nile water contains on the one hand, more calcium and magnesium compounds, and on the other much less of the alkali carbonates.

In order to appreciate the bearing of the above upon the condition of the water, it will be well to rehearse some of the facts which have been determined as to the suspension of clay in water, and its precipitation by various agents.

Ordinary clay contains a certain proportion of what has been called true or "colloid" clay. When clay is mixed with pure water, this jelly-like colloid clay remains permanently suspended in it, no matter how long the mixture is allowed to stand at rest. Certain classes of bodies have been found to cause the precipitation of this clay, while others have a tendency to favour its diffusion. Among the bodies which cause coagulation and precipitation from suspension, are acids, calcium and magnesium compounds, and certain salts—especially common salt. Alkaline substances, on the other hand, favour diffusion of the clay in water. Ammonia is especially active in this respect, but sodium carbonate is also very effective. Schloesing has pointed out that the clearness or turbidity of river water depends essentially on the proportion of calcium and magnesium compounds present. According to him, for a stream to be able to clear itself of the clay brought into it, the water must contain 70 to 80 parts of lime and magnesia per million.

Cause of difference in colour

Both Blue and White Nile waters contain a higher proportion of soluble matter during the season of lower water, especially from March till June. This is due not so much to the evaporation and concentration of the water as to the fact that at this time the river derives its supply in part from the water which has passed into the soil during the period of flood. At this latter season, both the waters contain less calcium and magnesium compounds, and in addition, the White Nile contains a comparatively high proportion of sodium and potassium bicarbonates and carbonates. Neither river is therefore able to free itself from the clay brought into it, and their waters remain turbid, even though allowed to stand at rest for a long time. When, later, the influx of subsoil water takes place, the proportion of lime and magnesia increases very appreciably. Thus in June the sum of the lime and magnesia in

Blue Nile water was equal to 45 parts per million. This is less than Schloesing's limit (70); nevertheless, by reason of the long distance over which the river passes, the, at this season, more moderate speed of the current, and the fact that no additional clay is brought into it, the river is able to clear itself almost completely of its suspended matter, and the water appears blue. In the same month the White Nile water contained but little less lime and magnesia (40 parts per million), but the proportion of alkali and bicarbonates was so high (equivalent in alkalinity to 90 parts of sodium carbonate) that the clay remained obstinately diffused in the water, which thus continued turbid ("white") throughout the entire year.

Absence of sulphates from White Nile water

Absence of Sulphates from White Nile Water

Blue Nile water was found to contain a small proportion of sulphates, ranging from about 5 to 7 parts of SO_4 per million. White Nile water, on the contrary, was found to be quite free from them. From March till June a minute proportion (about 1 part of SO_4 per million) was detected, but this was doubtless derived from the subsoil water which had filtered into the river during the period of low water. The explanation of the above exceptional condition was found during the examination of a series of samples of White Nile water collected by the Irrigation Department. These samples were unfortunately too small in bulk to permit of many determinations, and, moreover, the corks used had evidently, in some cases, contaminated the water. The results, so far as they went were, however, instructive, especially as regards the question of the sulphates.

Sample taken at	Nature of region	Sulphates, parts per million (SO_4)
Gondokoro	South of sudd region	5·70
Mongalla	,, ,,	5·75
Lake Powendael	Region of grassy swamps	Traces only
Ghaba Shambe	Region of papyrus swamps	None
Hellet Nuer	,, ,,	,,
Sobat River	Swampy	,,
Khartoum, up stream	Far north of swamp region	,,

It will be seen that the White Nile water, before it reached the sudd region, contained about the same proportion of sulphates as the Blue Nile water at Khartoum. By the time it had reached Lake Powendael, after having passed through a long stretch of grassy swamps, the sulphates were reduced to mere traces; and after having traversed the sudd region as far as Ghaba Shambe, they were removed altogether and failed to reappear even as far north as Khartoum.

Cause of absence of sulphates

The explanation of the disappearance of sulphates in the swampy regions is, no doubt, the same as that which accounts for the formation of sodium carbonate from sodium sulphate in the alkali lakes which are common to Egypt and similar hot, dry countries. In the presence of a large excess of organic matter, and the consequent limited supply of oxygen, sulphates are readily reduced to sulphides under the influence of micro-organisms. These sulphides are converted into carbonates by the carbonic acid formed at the same time, and the hydrogen sulphide is set free. Other decompositions also take place, and inflammable gases in considerable amount are constantly given off in these swampy districts.

A sample of the mud taken from the bed of Bahr-El-Zeraf by a dredger, was recently submitted by Mr. Dupuis, Inspector-General of Irrigation, for examination. When freshly brought to the surface the mud had a greenish-black colour, due to the presence of iron sulphide, formed as a result of the reduction of the sulphates. On exposure to the air oxidation of the iron sulphide takes place, and the mud becomes reddish-yellow.

The Sobat River water is also seen to be free from sulphates. This is to be expected, as the river derives its water from extensive swamps in which all its tributaries meet.

Since the above was written, the following analyses of waters from the White Nile, in the Sudd region, have been made. The point furthermost south from which it was possible to take samples was at Bor. This is in the beginning of the marshy regions, and it will be seen that the sulphates have already been reduced to a very low proportion—about one part per million. A little further on, and the last trace of sulphates is found to disappear. The amount of "oxygen absorbed," which is a measure of the organic matter present, is seen to increase steadily during the river's passage through the Sudd, up to the point at which the Sobat River joins the Nile, where there is a sudden marked fall. The effect of the decomposition of the vegetable matter and the solution of its mineral constituent is also traced in the proportions of potassium and sodium, which are subject to a steady rise, and a fall at the point mentioned above. It will be noticed that these waters, when they had arrived at Khartoum, with the exception of the first, were all able to clear themselves; a certain amount of sediment, largely organic, was present, but the water itself was clear. The organic matter present had evidently acted as a precipitant to the clay, just as do acids, calcium and magnesium salts, and those already mentioned. After the river passes a point beyond Kodok the large amount of alkali carbonates, resulting from the decompositions in the Sudd region, cause clay to be taken up from the soil in the river bed. The river again becomes turbid, and remains so for the rest of its course, except at the time of lowest water and after its junction with the Blue Nile, by which the proportion of alkali carbonates are reduced, by dilution, and the relative proportion of calcium and magnesium increased at the same time.

Precipitation of clay by organic matter

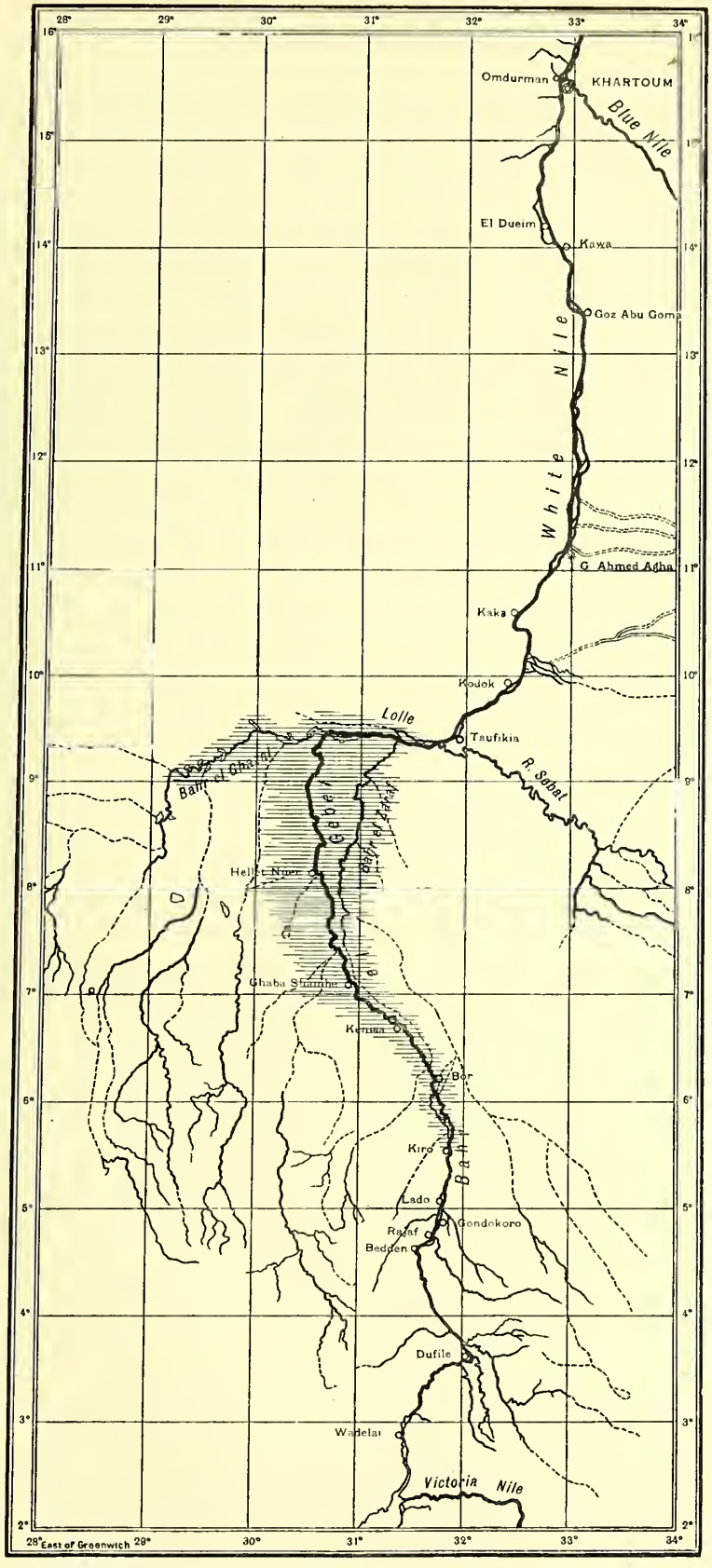


FIG. 94.—MAP OF SUDD REGION
Swamps or Sudd Country indicated by shading.

ANALYSES OF WATER FROM THE WHITE NILE, IN THE SUDD REGION

Analyses of river water in Sudd region

Number.	307	308	309	310	311	312
Point of collection	Bor	Between Kenissa and Ghaba Shambe	Hellet Nuer	Down stream of Lake No	Between Taufikia and mouth of Sobat R.	Kodok
Condition of water when sample arrived at Khartoum	Slightly opaleseent. Faintly eoloured. Some sediment	Clear. Brownish. Some sediment	Clear, with dark brown sediment. Water darker in eolour than No. 308	Clear, with dark brown sediment. Water darker in tint than No. 309	Clear. Some sediment. Water lighter in tint than No. 310	Clear, with sediment. Lighter in tint than No. 311. Only faintly coloured
Oxygen absorbed in 10 minutes at 100° C.	4·40	4·64	5·52	6·08	5·36	5·56
Chlorides ... ... (Cl)	7·74	7·18	7·50	8·88	3·59	5·48
Sulphates ... ...(SO_4)	1·12	None	None	None	None	None
Carbonates* ... ... (CO_3)	58·56	59·93	67·46	74·96	55·41	49·47
Caleium ... ... (Ca)	9·74	9·74	9·34	10·53	9·74	10·18
Magnesium .. .. (Mg)	4·41	4·54	3·61	4·28	3·49	3·85
Sodium ... ... (Na)	24·32	25·83	35·59	30·29	12·70	23·45
Potassium .. .. (K)	13·21	15·30	17·39	17·56	7·48	11·21

* See note in connection with Table on page 208.

Milk Supply of Khartoum

A dairy under Government management exists in Khartoum, and during the five colder months a limited amount of milk and butter of good quality is obtainable from it. For the rest of the year no butter is to be had, and the only milk available is that supplied by the native vendors. Most of this is goat's milk, but a few cows are also kept for the purpose. In 1904, a number of samples obtained in the Khartoum Sûk were examined, but these, while leaving much to be desired as regards cleanliness, were evidently whole milk, undiluted and unskimmed. Recently, attention was called to the poor quality of the milk supplied to the Civil Hospital, and examination showed it to contain about 25 per cent. of added water. Once started on this apparently royal road to fortune, the native milk-seller could see no reason for moderation in his pace. The milk supplied to the Grand Hotel, for instance, gave the following results on analysis :—

Milk adulteration

	Oct. 17	Oct. 18	Oct. 19
Total Solids	3·55	3·36	3·20 per cent.
Fat	1·35	1·30	1·22 ,, ,,
Solids not fat ..	2·20	2·06	1·98 ,, ,,

The average total solids of the goat's milk already examined was over 13 per cent. The above milk (?) evidently contained something like 75 per cent. of added water. Whether, ultimately, delicate tests would have discovered as much as a faint trace of fatty and non-fatty solids in Khartoum milk, had not the Medical Officer of Health stepped in and

by punishing and registering the milk vendors, cruelly put a stop to such sources of income, would seem to be doubtful. One of these worthies, when accused of carrying her worship of the Nile to undue lengths, naively replied "Malum! I make more money like that."

Systematic examinations of the milk of individual cows and goats, as well as of the mixed milk of herds of each of these, have been begun, and it is proposed to continue them in order to accumulate data which will enable one to establish a standard or standards, applicable to all seasons of the year. The fact that the milk supply is derived partly from goats and partly from cows introduces a difficulty, since the "solids not fat," of goat's milk is, as a rule, at least in other countries, considerably higher than that of cow's milk. So far as the present results go the milk from Khartoum cows appears to be quite equal to that from goats; but it is not anticipated, when all the results are in, that these high proportions will be maintained.

Analyses of pure milks

The following are some of the results which have been obtained from the examination of milk of individual animals:—

No.	275	280	283	284	278	279	282
Milk from	Goat	Goat	Goat	Goat	Egyptian Cow	Sudanese Cow	Cow
Quantity	—	1 pint	—	—	4 pints	1½ pints	—
Period since calving	—	4 months	—	—	8 months	6 months	—
Total solids	13·6	14·80	13·6	14·81	13·0	16·51	15·01
Fat	4·0	4·35	4·7	5·35	3·5	7·40	6·35
Solids not fat	9·6	10·45	8·9	9·46	9·5	9·11	8·66

Samples Nos. 280, 278 and 279 were collected by Mr. W. A. Davie; the remainder by Mr. Newlove.

One sample from a cow brought north from Kodok, suffering from trpyanosomiasis, but since apparently cured, gave the following exceptionally high figures. The yield of milk was not noted. The cow had calved eight months previously.

Total Solids	21·5 per cent.
Fat	11·2 „
Solids not fat	10·3 „

Dried Milks

Dried milks

Milk powders, prepared by evaporating milks to dryness on a revolving cylinder, heated to 230° F. have been on the market for the last two years or more. Milk in this form would appear to be exceptionally suited to use in the Sudan, especially by those journeying in the interior where ordinary milk is frequently not obtainable. As a result of the heat used in manufacture these powders have been found to be bacteriologically sterile, and samples kept in the laboratory for five months at a temperature of from 85° to 98° were still found to be in fairly good condition.

Perhaps the best method of reconstituting milk from such powders is to bring water to boiling and allow to cool to about 160° to 180° F.; the powder is then made into a paste with a small portion of the water; more of the water is then added until the milk has the strength desired. Milk so reconstituted is difficult to distinguish from ordinary milk, and is of very agreeable flavour and odour.

Press of other work has prevented an exhaustive examination of this reconstituted milk, but sufficient evidence was gathered to make it extremely likely that it would be found considerably more digestible than ordinary milk. Thus it was noted that when the milk was curdled with rennet the curd formed was in fine flakes, and not in one large clot as is the case with ordinary milk. The curd formed by dilute acid was also more finely divided.

Digestibility

The natural inference from this is that its digestion would be facilitated. This was borne out by the experience with a patient with whom ordinary milk was found far less readily digested. Recently Somerville* has noted similar effects as regards the action of rennet on ordinary and reconstituted milk, and, in a series of artificial digestions, has found both the fat and proteids in the latter be in more digestible form.

Analyses

Analysis of Commercial Dried Milks

Brand	Form	Moisture	Fat	Lactose and Proteids	Ash
"Golden Vale Full Cream"	Tablets of 30 grammes	4·61	25·52	62·67	7·00
"Golden Vale Full Cream"	Powder in tins	4·82	24·52	63·69	6·79
"Lacta. Dried English Full Cream" ...	Powder in tins	5·00	24·30	64·05	6·65
"Galak. Half Cream"	Powder in tins	6·10	16·35	70·33	7·22

All of these are of the strength claimed for them by the makers. The last sample, "Galak," made from milk from which half of the cream has been abstracted, keeps in good condition longer than the other in powder form, but is not economical in use. For most purposes, as, for instance, in tea and coffee, about double the quantity has to be used in order to produce the same apparent effect as with "full cream" milks. The tablet form of "Golden Vale" kept sweet longer than the powder of the same milk, is much cheaper and from its small bulk more convenient for transport; but it was found more difficult with it to reconstitute the milk free from lumps and flakes of considerable size.

Some Analyses of Sudan Grains

The following analyses of wheat grown in the Sudan are of interest, not only because of the excellent quality which they disclose, but especially in view of the possibility of utilizing for its cultivation extensive areas where the supply of water is at present insufficient for the successful production of cotton. A market for this wheat could be found in the neighbouring countries bordering on the Red Sea and possibly in Egypt as well.

Sudan wheat for Egyptian consumption

In Egypt, by reason of the extension of perennial irrigation, the cultivation of wheat, already insufficient to meet the requirements of the country, has decreased in recent years. A rapidly increasing population has caused a still further shortage and the demand for bread stuffs has to be met by imports from abroad.† Since it is contemplated bringing still

* Laboratory experiments on the digestibility of dried milk. *Public Health*, October, 1905, p. 40.

† The imports of wheat as grain and flour amounted in 1905 to £E1,215,243.

more land under perennial irrigation, the shortage is likely to be very considerably increased. There seems to be no good reason why this demand should not be met by the Sudan.

Analyses of Wheat

No. 219. Seed unknown. Bought in Omdurman market. Sent by Bimb. Huskisson, Staff Officer Supplies, Sudan, S.

No. 220. Indian. Reproduced at the Experimental Farm for three years.

No. 221. Indian (Mozaffarnagar). Reproduced at the Experimental Farm for two years.

No. 222. Egyptian. Reproduced at the Experimental Farm for two years.

No. 223. Sudani. Sown on the Experimental Farm for two years.

Nos. 220 to 223 inclusive were sent by Mr. Broun, Dir. of Agriculture and Lands.

Number	219	220	221	222	223
Variety of seed	Unknown Omdurman	Indian	Indian (Mozaffarnagar)	Egyptian	Sudani
Moisture	4·37	4·87	4·50	4·60	4·95
Fat (Ether extract)	1·50	1·70	1·58	1·55	1·70
Albuminoids (N × 5·68)	11·01	17·87	14·83	21·00	21·53
Non-nitrogenous extract	77·74	69·66	73·82	69·20	66·37
Crude fibre	2·90	3·40	2·98	3·35	3·35
Mineral matter (ash)	2·48	2·50	2·29	2·30	2·10
Weight of 100 grains (in grammes)	2·813	2·716	2·795	3·139	2·465

Analyses of Millets and Maize

Number	200	201	202	203	239	240	297
Description	Maize Dura Shami	Dura White Feterita	Dura Red Feterita	Dura Brown Feterita	Telebun	Teff	Dukhn
	Zea Mays	*Sorghum vulgare*			*Eleusine Corocana*	*Poa Abyssinica*	*Pencillaria spicata*
Where produced ...	...	El Halawin, Ghezireh Province, near Kamlin	Goz Abu Goma	Blue Nile at Singa	Wau	Kassala	Kordofan
Moisture	4·97	6·20	4·90	6·17	7·35	5·69	4·40
Fat (Ether extract) ...	5·17	3·02	3·00	2·77	1·25	2·80	3·30
Albuminoids (N × 6·25)	13·02	12·31	14·18	8·93	5·28	5·91	16·71
Non-nitrogenous extract	70·47	74·57	73·77	78·67	81·26	80·60	70·49
Crude fibre	2·15	1·80	2·10	1·72	2·85	2·70	3·55
Mineral matter (ash) ...	2·20	2·10	2·05	1·67	2·01	2·30	1·51
Weight of 100 grains ... (in grammes)	17·37	3·60	3·787	2·567	0·215	0·025	0·757

Sudan millets and maize

Leguminous Seeds

The following analyses were made at the request of Colonel Asser, former Civil Secretary, with the object of finding a grain, grown in the Sudan, which might be substituted for the Egyptian lentils issued as a ration to the native troops:—

Leguminous seeds

Number	177	178	179	180
Grain	Egyptian Lentils *Lens esculenta*	Sudan Lentils *Cajanus indicus*	Kashrangeek *Vigna sinensis*	Lubia *Dolichos lablab*
Moisture	6·22	6·20	6·35	5·70
Fat (Ether extract)	0·96	1·37	0·90	0·93
Albuminoids (N × 6·25)	27·30	21·63	25·52	26·60
Non-nitrogenous extract	57·40	61·80	54·23	58·02
Crude fibre	5·12	6·40	9·15	4·90
Mineral matter (ash)	3·00	3·60	3·85	3·85

It will be seen that the Sudan lubia are almost identical in composition with the Egyptian lentils, and much more nearly so than the variety of lentils grown in the Sudan.

A sample of gram grown at the Experimental Farm, from Indian seed, had the following composition:—

Moisture	3·95 per cent.
Fat (Ether extract)	3·75 „
Albuminoids (N × 6·25)	19·47 „
Non-nitrogenous extract	62·51 „
Crude fibre	8·20 „
Mineral matter (ash)	3·82 „
Weight of 100 grains	15·417 grammes.

Salt

The greater portion of the salt used in the Sudan is manufactured locally. The methods of extraction used are crude, and the quality of the worst. In most cases the salt contains a considerable proportion of insoluble matter—sand and clay. This is especially the case with the article sold in the form of cones similar to loaves of sugar, which are generally in use. In addition to this, cone salt often contains such a large proportion of foreign salts, especially sodium sulphate, as to make it distinctly aperient or purgative. This fact is recognized by the native, and the salt is sometimes used medicinally. An example of such salt is had in the sample from Rubatab country, in which the sodium sulphate amounts to over 18 per cent.

Native made salt

Analyses of Salt of Native Manufacture

—	Small cone, Rubatab country	Large cone, El Damer	Loose salt, El Damer	Loose salt, Rufaa
Clay and other dirt insoluble in water...	0·53	5·84	0·40	0·31
Calcium sulphate	0·54	2·70	1·70	1·16
Calcium chloride	—	5·26	3·20	4·60
Magnesium chloride	0·44	1·99	2·63	5·30
Sodium sulphate	18·64	—	—	—
Salt (and moisture) by diff.	80·05	84·21	92·17	88·63
——	100·00	100·00	100·00	100·00

Method of extraction

The process of extraction consists in treating the salt-containing earth with water, drawing off the more or less clear liquid and boiling down in small pans. The cone salt is made by boiling down in a clay mould. It will be seen that the loose salt is both cleaner and purer, but at best is of very poor quality. The sample from El Damer has a dirty appearance. That from Rufaa looks cleaner, but has a brownish colour.

The salt used by the Government for issue to both men and animals is that imported from Egypt, obtained by the evaporation of the salt lakes near Mex. The analysis of one sample gave the following results:

Analysis of Salt from Mex

Insoluble in water	0·05 per cent.
Calcium sulphate	0·62 „
Magnesium chloride	0·08 „
Sodium sulphate	0·27 „
Sodium chloride (and moisture)	98·98 „

Salt obtained from this source varies somewhat in composition, but will rarely contain more than twice the amount of impurity stated above.

Dongola salt

All the above samples were kindly furnished us by Major Coutts, Assistant Civil Secretary, to whom we are indebted also for the following sample of exceptionally good salt from the desert in the Dongola district, where it is said to exist in considerable quantity.

Analysis of Salt from Desert near Dongola

Insoluble in water	0·05 per cent.
Calcium compounds	Traces only.
Magnesium sulphate	0·22 per cent.
True salt	99·73 „

The above figures are calculated on the salt free from hygroscopic moisture.

Exceptionally pure salt from natron lake

I am informed that natron is also found in the district, and probably the two are derived from the bed of a natron lake which formerly existed there. When in charge of the Wady Natron, in Egypt, it was noticed that at certain seasons of the year it was possible to scrape from the beds of some of the lakes a salt of almost absolute purity. The impurities present were only minute proportions of sodium carbonate and sulphate, not even a trace of calcium nor magnesium being found. The freedom from these was evidently due to the presence of a very large proportion of sodium carbonate in the mother liquor. Salts of the above composition attract moisture from the air only when the latter is excessively damp. The

following is an analysis of salt crystals taken from the bed of Lake Rouzanieh, in the Wady Natron.

Sodium sulphate	0·04 per cent.
Sodium carbonate	0·11 „
True salt (by diff.)	99·85 „

The above impurity, slight as it was, was derived largely from the lake water which adhered to the surface of the crystals. After slight washing in comparatively fresh water, the crystals, after drying, had the following composition :

Sodium sulphate	0·04 per cent.
Sodium carbonate	0·04 „
True salt	99·92 „

"Male" and "female" salt

"*Male*" *and* "*Female*" *Salt.*—We are indebted to Mr. Türstig of the Egyptian Survey Department for the following samples which were collected near Khor Tomāt, several hundred miles up the Atbara river. At this place salt is extracted from earths which contain only a little over two per cent., by leaching with water and boiling down in the usual way. The interesting point was noted that the natives employ for the purpose two different earths, one containing what they term "male" and the other "female" salt. Neither of these, it was stated, was edible if taken alone, but if the earths are mixed they furnished a salt of good quality. The results of analyses bore out these statements. 100 grammes of each of the earths were found to contain the following proportions of soluble salts :

—	Male	Female
	Per cent.	Per cent.
Sodium chloride	1·580	1·178
Sodium sulphate	0·443	—
Calcium chloride	—	0·821
Calcium sulphate	0·292	0·170
Magnesium chloride	0·135	0·174
Total	2·450	2·343

As will be seen, the "male" salt contains such a large proportion of sodium sulphate as would render it of little use as a table salt. Similarly the "female" salt contains an excessive proportion of calcium chloride. By combining the two in about the proportion of say two parts of male to one part of female, the two impurities would unite to form calcium sulphate, and the proportion of sodium chloride would be notably increased. On boiling down, the calcium sulphate would separate, in part, and from the concentrated mother liquor a good quality of salt could be obtained by further evaporation.

Limestone and Lime

The extension of building operations in the Sudan has created an increasing demand for lime of good quality. Beds of what would usually be considered to be good limestone are not plentiful, especially in the neighbourhood of Khartoum. Most of the deposits are of very irregular character and mixed with more or less, usually very

considerable, sand and clayey matter. The Department of Works experienced considerable difficulty in employing the lime made from this material, especially in interiors where the plaster was found to blister and peel. Mr. F. Murphy, of the same Department, called my attention to the exceptionally poor quality of the mortar used in the construction of certain buildings. In places, I was told, the mortar could not only be scraped away with the greatest ease, but once the outer covering was removed, the interior was found to run away almost as readily as loose sand. Samples of lime from several sources, used for this purpose, were sent to the laboratories for examination. One of these was only tested qualitatively. It was found to contain no lime at all—evidently a mistake in the sampling. Two other samples gave the following results:—

Marks	Pasquali	Lolos
True Lime (C_a O)	58·3 ...	54 7
Sand, Clay, etc....	28·1 ...	31·8
Undet.	13·6 ...	13·5
TOTAL	100·0	100·0

There was nothing in these figures to account for the unsatisfactory results obtained. Ultimately the explanation was found in the method of working. As already mentioned, the limestone near Khartoum is of very irregular quality and contains a considerable amount of foreign stone. As it is not easy, by mere inspection, to detect this useless material in the burnt lime, nor to estimate the amount present, it has been the practice of contractors to purchase the lime only after it has been slaked and the worthless material sifted out. There would be little objection to this method provided the lime were used at once; but, as a matter of fact, it was delivered, or used, in many cases, days and even weeks after slaking. With lime of like composition such a practice is fatal. In the presence of so large an amount of clay, the lime "sets" to a certain extent, like a cement, and the best results can only be had by using as quickly as possible after slaking. Of course, where the lime has been allowed to stand, slaked, and in dry powder, for weeks, not only is the effect of the hydraulic character of the lime lost, but absorption of carbon dioxide from the air takes place to such an extent that the lime becomes practically worthless. These points were quickly grasped by Mr. Murphy and the energetic measures taken to insure the use only of freshly-slaked lime were followed, we are informed, by satisfactory results.

Cause of bad quality of lime

The ideal method of employing lime of this hydraulic character is that which, as I am informed by Mr. Dupuis, obtains in India. The lime is derived from a so-called "kankery" formation, consisting of nodules and root-like masses containing, in addition to calcium carbonate, a considerable proportion of clay and sand. This is burnt with wood in rather shallow kilns. After cooling the entire mass is ground, and the powder so obtained furnishes an excellent hydraulic lime. In use, water is only added at the time the admixture with sand or other material, is made. The maximum hydraulic effect is secured in this way.

"Kanker" limestone

Foreseeing the need for lime for building purposes throughout the Sudan, a number of samples of limestone were collected by Mr. Dupuis, Inspector General of the Sudan Irrigation Service. Some of these are "kankery" formations, similar to those of India, and there is every reason to believe that excellent results would be had by treating the lime produced from them either in the ordinary way, or, if hydraulic lime is required, by the Indian method detailed above. Others are more nearly pure limestone and would furnish a

good quality of what is known as "fat" lime. As will be seen, these samples have been taken from many localities and range over practically the whole of the Sudan.

Analyses of limestones

C. L. No.	Marks	Character	Locality	Calcium Carbonate	Magnesium Carbonate	Alumina	Ferric Oxide	Total Silica	Sand and Clay
151	1	Black nodular masses found in soil	Kamlin'...	82·57	3·70	2·72	1.78	6·80	8·80
152	2	White „ „ „ „	„	78·48	4·16	2·69	1.97	7·20	10·20
153	3	Root shaped „ „ „	Blue Nile banks ...	46·47	4·83	5·00	2.66	28·35	35·65
154	4	„ „ „ „ „	„ „ „ ...	50·27	5·00	6·88	3.45	22·65	29·85
155	5	„ „ „ „ „	„ „ „ ...	59·45	2·66	5·20	2.87	18·05	23·55
181	—	Nodules from river bank	Bor	73·70	2·78	3·14	1.84	15·85	20·80
182	—	„ in soil	Binney and Fatoyitch	72·95	3·00	3·04	2.16	17·65	22·35
183	—	„ on surface of soil ...	Bet. Taufikia and Bor	66·40	2·88	5·43	3.52	20·50	26·75
198	—	Nodules	Sobat at Abwong ...	75·52	4·25	3·24	2.56	12·85	16·40
265	6	White crystalline limestone ...	Near Roseires	87·50	0·22	0·50		11·35	—
266	7	Pink „ „ ...	„ „	94·45	1·21	0·65		3·00	—
267	8	Coarse granular stone	J. Gereirissa	43·15	2·34	2·70		—	51·70
268	9	Crystalline	Sabderat near Kassala	66·25	32·11	0·30		1·15	—
269	10	Nodular	Bor Wood Station ...	72·30	4·16	3·80		—	19·30
270	11	„	Ghaba Shambe... ...	69·50	3·02	3·10		—	23·80
271	12	„ from river bank... ...	near Taufikia	71·55	4·84	4·10		—	18·70
272	13	„ „ „ „	„ Melut	77·95	4·18	2·77		—	14·20
273	14	„ „ „ „	Lower Bahr el Ghazal	72·23	4·12	5·30		—	17·40

No. 198 was furnished by Kaim. H. H. Wilson.

Sudan "Gum Arabic"

Gum arabic

Gum arabic has been known from the remotest antiquity. Nearly 2,000 years B.C. it was used by the Egyptians in the fabrication of colours for painting. The gum was collected in the valley of the Nile from the *Acacia Arabica*, which formerly grew there in abundance, but the greater portion was imported into the country by vessels coming from Aden, which port probably derived its supply only in part from the interior of Arabia—a portion having its origin along the Somali coast. Later, under Roman domination, and in the Middle Ages, the gum exported from Aden was chiefly, if not entirely, that from Somaliland. Much larger quantities were produced in Arabia and exported from Jeddah, on the Red Sea to Europe. At the present time the Arabs pay comparatively little attention to the production of gum, the two great gum producing countries being the Anglo-Egyptian Sudan and the French Colony of Senegal.

During the years of the Dervish occupation, trade in gum ceased; but with the reconquering of the Sudan it was renewed, and it is expected that the Sudan product will regain its former place in the front rank of the trade of this article.

In the Sudan, as in Senegal, gum is exuded from a number of varieties of acacias, but, in both countries, the chief variety, and that furnishing the class of gum which has the

Fig. 95.—Gum Market on Foreshore at Omdurman

Source of gum

highest commercial value, is the *Acacia Verek* known in Senegal as the *Acacia Senegal*, and in the Sudan as *Hashaba* (pl. *Hashab*). A much smaller quantity of gum called *Talh* is collected in the Sudan from the *A. Seyal*. The *A. Arabica* (*Santa*, pl. *Sant*) and other varieties exist and exude gums, but these, either because of their dark colour or other objectionable qualities are of no commercial importance.

Growth and Collection—The conditions of cultivation and collection of gum have been noted by C. E. Muriel,* former Director of Forests, as follows:—

"Hashab Gum.—The best gum ('Hashab') comes chiefly from Kordofan; a small quantity, is collected on the Blue Nile, and is known as 'Hashab Gezireh.' Hashab gum is also reported as plentiful in Kassala. 'Hashab Geneina,' is the term applied to the gum when it is obtained from the specially worked trees which constitute the Kordofan Geneinas. Soon after the rains have ceased, bark is removed in strips from the principal branches of all *Hashab* trees of three years old and upwards in the Geneina.

"The operation is performed by men armed with the common axe of the country, with which the bark is cut through transversely and then torn off in a strip by hand: if carefully done a thin layer of the inner bark (liber) is left covering the wood, and the tree is not much injured.

"Strips of 2 to 3 feet in length, and 1 to 3 inches wide—more or less according to the size of the branch operated on—appear to give best results.

Collection of gum

"In some cases where long strips of bark 6 feet or more in length had been torn off, less gum seemed to exude, than where short lengths of bark had been removed.

"The removal of bark down to the wood and cutting into the wood itself should be avoided; in such cases, less gum exudes, and the tree is injured. Dead branches, and small side branchlets are cleared away when barking is done to facilitate approach to the tree, for collecting the gum.

"Some sixty days after barking, the first collection of gum is made, and thereafter the Geneina is completely picked over every fourth day, until the flush of new leaves soon after the rains set in, stops the exudation of gum. Gum picking is chiefly done by women.

"'Hashab Wady' is the name applied to gum which is exuded naturally from *Hashab* trees not included in Geneina.

"This gum is slightly darker in colour than 'Hashab Geneina,' but it is possible to select clean pieces of 'Wady' gum which cannot be distinguished by the gum pickers themselves from 'Geneina' gum.

"'Wady'† gum is usually in pear-shaped pieces of variable size, proportionate to the length of time that elapses, between consecutive collections (ten days to a month, and the more distant Wady forest is only picked over once a year).

"'Kadab' is the name given to a dirty gum which is sometimes found exuding from *Hashab* trees. It is of no value, and if found in a parcel of gum is picked out, and thrown away.

"The conditions favourable to the production of 'Hashab' gum are:—Ferruginous, sandy soil, with a good natural drainage; dry heat during the gum collecting season, and a moderately heavy rainfall (40 to 70 inches) during the rainy season.

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* Report on the Forests of the Sudan. C. E. Muriel, October, 1901.

† In a recent report Mr. Broun, Director of Woods and Forests, notes that the term "Wady" is now applied to certain large coloured tears of either Wady or Geneina origin.

" Excessive moisture in soil, otherwise suitable, appears to prevent the production of gum. Near Agari, where the Khor Agari loses itself in the sandy soil, there is a good growth of *Hashab*, but on these trees no trace of gum was found, though on either side there is good gum producing Geneina. Trees on such moist soils preserve their leaves, and it seems probable that shade is in such cases, the main cause preventing the formation of gum, just as the flush of new leaves, when the rains commence, stops the further production of gum for the season, on gum bearing trees. Conditions favouring gum production

" Protection from fire is essential to success. Burnt Geneina is unproductive for the rest of the season. This is known, and acted on by the people, who are extremely cautious in the use of fire, so that although they do not take more active measures of fire protection only a comparatively small area of burnt Geneina was seen.

" The main causes of such fires as do occur, seem to be the careless burning of grass on the paths by camel men, and malicious firing by gum pickers (living in villages not frequented by gum merchants) of Geneina, near the villages at which the merchants reside during the gum season ; the object being (by lessening the supply of gum at the latter places) to induce the merchants to move on to the other villages.

" The clearing of fire traces would safeguard the Geneinas from accidental fires, and would render the detection of malicious firing less difficult, as incendiaries would have to go into the Geneinas to set fire to them, instead of merely lighting the grass to windward at a distance. Adequate punishment in proved cases of malicious firing is the only means of stopping the offence. Regarding the age of gum producing trees 3 to 15 or 20 years may be taken as the limits ; the lower limit is essentially one of size rather than age. Young *Hashab* 8 to 10 feet high, with a girth of 6 to 8 inches, will produce gum.

" From an examination of trees in various localities which were producing little or no gum, and in Geneinas considered past bearing, it appears that at about 12 to 15 years of age the *Hashab* tree forms a dark brownish black heartwood, and thereafter the production of gum diminishes, and subsequently ceases. Probably trees of 8 to 12 years yield the best return of gum.

" Much might be done to increase the production of gum by filling up blanks in Geneinas. It would be easy to collect seeds from the other trees in the Geneina, and drop them about at intervals of six yards in the blank spaces. Such sowing had best be made just when the rains commence, so that the seeds may germinate as soon as possible after sowing—if made earlier many of the seeds would be eaten by rats.

" Crowding of trees in a Geneina is not desirable, as it is gum, and not timber, that is the marketable produce. A complete canopy would give too much shade and lessen the exudation of gum, also a much-branched tree has a proportionately greater gum-bearing surface.

" A stock of 18 to 100 trees per acre would be dense enough, and sowings as indicated above would (allowing for failures) produce sufficient seedlings.

" In addition to the advantage of maximum yield obtained by having a fully stocked Geneina, the risk of serious damage by fire is much less than where trees are scattered, and the absence of shade allows a thick growth of grass to spring up.

" As population increases, areas of Wady will come to be treated as Geneina, yielding a purer gum and more of it.

" The management of Geneinas is best left in private hands, the operator is then directly interested, and uses all care in the barking of the trees and the collection of gum.

" The present needs are more people to take up Geneina, and wells to enable them to

establish villages near suitable tracts of Wady. Food stuffs can be bought or exchanged for gum, but often some dukhn is cultivated by Geneina owners.

" The quantity of gum produced on a given area varies very much (according to the stock of trees).

Yield of gum

" On an average Geneina near Shergeila, area about 10 acres, the owner stated that the first collection yielded about 100 lbs. of gum, dropping to 75 lbs. and 60 lbs. at the second and third picking. After that it averaged about 50 lbs. each for several collections, and goes on diminishing to 10 lbs. at the close of the season. He estimated the annual yield at 12 or 15 Kantars (1,200 to 1,500 lbs.).

" Near Agari, where the Geneina were much better, the estimate for 30 Geneinas for the season was 700 Kantars (70,000 lbs.), of which 470 Kantars had then (7th April) been collected.

" For equal areas the out-turn at Agari, would be about double that at Shergeila, due chiefly to the want of density in the stock of trees in the Shergeila Geneinas.

Talh

" Talh Gum.—Talh gum is collected chiefly from the Blue Nile forests; these were visited before the gum collecting season had commenced, consequently the work of collecting was not seen.

" According to the information obtained the *Talh* trees are not barked or wounded in any way by gum collectors, who take such pieces of gum as they find exuding from the trees. It is impossible to form any estimate of the immense area over which the *Talh* Acacia grows. There are two varieties of trees, one with a red powder which so covers the bark of the tree as to make it appear entirely red, is called *Red Talh*, the other is similarly coated with a white powder, has a staring white appearance, and is generally called *White Talh*, but bears also the name *Soffar*, from the fact that the base of its stipular spines are usually enlarged by the puncture of some insect which deposits its eggs there, the larva emerging makes a small hole through the globular enlargement and the wind blowing on this produces a whistling sound.

" Both varieties produce gums, which appear to be indistinguishable, but the *Red Talh* being very much more abundant than the White, it is from that variety that most of the *Talh* gum is obtained.

" The localities where this gum is collected in quantity are in the Karkoj Mamuria, and the South part of the Wad-El-Abbas Mamuria. A small quantity is also collected in the Roseires District. A comparatively small quantity is extracted from the forests West of Kaka on the White Nile."

Origin of gum

Origin of Gum.—According to the recent researches of Greig Smith* the production of gum is due to a specific microbe, which he has named *Bact. acaciæ*. The gum has been shown to be formed from the wandering sugars, levulose and maltose, in the sap. Another organism, *B. metarabinum*, was also isolated. This was found to produce the form of gum which swells up in water, but does not dissolve. Further, it was found that the host plant was able to convert *B. acaciæ* into *B. metarabinum*, thus proving that the latter organism is simply a variety of the former. It appears evident from these researches that *B. acaciæ* is the prime cause of the formation of gum in all varieties of acacias, the character of the gum formed depending upon the nature of the sap of the host. This would explain the uniformity of the gum from certain species of trees.

* Proeeedings of the Linnean Soeiety of New South Wales, 1902-3-4; J. Soe. Chem. Ind., Feb. and Oct., 1904.

Fig. 96.—Native Women Engaged in Gum Picking at Omdurman

Gum formation, *gummosis*, *gum flux*, in plants has long been held, at least in some cases, to be the result of a pathological condition. Maiden (Phar. Jour. 3, XX. (1890), 869), who considered it to be the general rule, quotes an observation of Trécul to the effect that Acacias and Rosaceæ yield their gums most abundantly when sickly or in an abnormal state. So far as regards the Sudan, and, it would appear Senegal as well, it is in sandy, not very rich soils, moist in the rainy, but deficient in moisture in the dryer season, that the trees seem to yield gum most abundantly. A plentiful supply of moisture at all seasons appears to result in a condition of vigour in the plant which enables it to resist infection. This would explain the state of affairs mentioned by Muriel (see page 225), who found a good growth of "Hashab" trees bearing no trace of gum, and yet, on either side, in dryer soil, there was a good gum producing Geneina. This also appears to be the case in the Blue Nile Province.

As Dr. Greig Smith (*loc. cit.*) states, while every susceptible tree does not produce gums it might be made to do so by an artificial infection, either with pure bacterial cultures or with the fresh juice from a selected and infected tree. The case cited above would seem to indicate that infection would only take place under certain favourable conditions. It seems little likely that the group of trees referred to would have remained uninfected, situated as they were, had they been susceptible; but it is quite possible that other acacias, differently situated, might have remained uninfected, and inoculation might be practised with profit. In any case, as Dr. Smith further notes, all branches of a tree may not be producing gum, and an artificial infection of these might increase the yield. There is, possibly, a very profitable field for research in this direction.

Uses of gum

Uses of Gum Arabic.—Gum arabic has a very wide application in the arts. The better grades are used in confectionery, in dyeing and finishing silks and other fabrics, in water colours and in pharmaceutical preparations. The lower grades are used in the manufacture of inks, matches, stationery, etc. The commercial value of the gum will depend principally upon its freedom from colour, odour, taste, and foreign matter, and upon its strength, as measured by the viscosity of its solutions.

Grading.—At the present time by far the larger portion of Sudan gum is exported in the crude state. A small amount of it is partially picked, and some of it, already of a light colour, is further bleached by exposure to the sun. The result is an almost perfectly white gum, yielding a nearly colourless solution, odourless and practically tasteless, or of a slight agreeable flavour. This grade is highly prized for use in confectionery.

Although all the gum from Kordofan is collected from the *Acacia Verek*, the gum presents certain differences in quality. How far these differences are due to soil, to the amount of rainfall and to season of collection, to the barking and age of the trees, etc., etc., has not as yet been worked out; the last mentioned, the age of the tree, seems to be a most important factor. Generally speaking, the stronger gum is the product of young, and the weaker variety of the more fully matured trees. In Trieste, where much of the gum goes for sorting and cleaning, the gum is divided into two main classes—"Khartoum" and "Kordofan." "Khartoum" is the hard gum, presenting more the characteristics of the Senegal product. The surface is smooth and shiny and the pieces are hard and tough. This gum yields a solution highly viscous, and, as a rule, of light colour.

So called "Khartoum" and "Kordofan" gums

The grade known as "Kordofan" is a softer gum, which in drying quickly becomes covered with innumerable cracks and fissures, so that after even a moderate exposure to the sun the tears lose their transparency and appear whitish and opaque. As a rule this variety of gum furnishes a very pale, clean solution of good flavour. The viscosity may be,

and usually is, lower than that of "Khartoum" gum, but whether because this is overbalanced by its other qualities, or because of different methods of working, this gum fetches in Trieste a higher price for use in confectionery than the harder and so-called "stronger" gum.

Grading

Senegal gum is picked to a great number of grades.* In the following tables of results of examinations, the Sudan gum was in some cases picked to the same grades in order to afford a better comparison. The latter was possible only with Kordofan Hashab, this season's gum from Gedaref and Ghezireh not yet being available.

The proportion of moisture was noted to be closely dependant upon the size of the tears, the smaller ones offering more evaporating surface and containing less water.

The amount of acidity varied but little. The sourish taste which some samples possess is not always associated with higher actual acidity. The determination of ash has little significance. In gums from the same variety of tree and the same immediate neighbourhood the darker tears have as a rule a very slightly higher ash. These darker gums are, as a rule, stronger, but not invariably so.

The colour of the Sudan hard gum picked as large white tears (*grosse blanche*, Senegal) was a shade darker than the corresponding grade of Senegal gum; the colour of the mucilage of equal strength was, however, almost identical. All the other grades of the Sudan gum and of the mixed (crude) gum were very considerably lighter than the same grade of Senegal gum—a point which tells strongly in favour of the Sudan product. The average strength† of the picked grades of hard Sudan gum is appreciably higher than that of the same grades of Senegal gum. All the crude (unpicked) Kordofan gums, that is, both the hard and the soft gums, show a higher strength than the unpicked Senegal gum. Thus the soft variety, unpicked, was found to possess a strength of 92·5, as against an average of 83 for the three samples of "Bas du Fleuve" tested.

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* Crude Senegal gum is divided into three main classes:—

1. Hard gum. *Gomme du bas du fleuve.* This consists of largish round, vermiform or irregular shaped tears, varying from almost colourless to dark yellow.

2. *Gomme du haut du fleuve.* This, the second grade, is obtained from Upper Senegal. The tears are smaller than those of "Bas du fleuve" and, on the whole, darker.

Both the above are derived in the main from the *A. Senegal* (*Acacia verek*), but they are often mixed with pieces of reddish colour, glassy, of bitter taste, due to the gum of the *A. arabica* and its varieties.

3. *Gomme friable.* This is the product largely of the *A. albieda* (White tree. Cedra beida or by corruption Sadra-beida and Salabreda).

The gum resembles coarse salt. It is very friable, and its solution has less viscosity than that of the gums already mentioned. It is usually in small fragments or vermiform tears. The latter are often almost colourless, but the fragments are usually dark coloured. The variety corresponds in quality to the Talh gum of the Sudan.

Senegal gum is picked into a great number of classes of which the principal are:—

(*a*) *La gomme grosse blanche*, in rather large tears, unbroken, colourless or slightly yellowish.

(*b*) *La gomme petite blanche*, which differs from the above only in that the tears are smaller.

(*c*) *La gomme grosse blonde*, in tears about the same size as those of gomme grosse blanche, but yellowish or reddish yellow.

(*d*) *La gomme petite blonde*, like the above but smaller.

(*e*) *La gomme deuxième blonde*, of a reddish colour.

(*f*) *La gomme vermicelle*, vermiform or branched tears, usually of light colour.

(*g*) *La gomme fabrique*, of which the pieces, of larger or smaller size (*fabrique* and *petite fabrique*) are not suitable for classification with any of the above.

(*h*) *La gomme marron*, dark coloured, very impure, containing much foreign matter—bark and other impurities.

(*i*) *La gomme friable*—already described above.

Broken gum is also sorted by sieves into *Gomme gros grabeaux*, *Gomme moyens grabeaux*, *Gomme menus grabeaux*, and *Gomme poussiere grabeaux.*

† This is measured by the viscosity of a solution of given strength, as compared with the viscosity of an average hard gum of the best quality. The method of determining the viscosity is detailed on pp. 232 and 233.

KORDOFAN GUM. CROP OF 1905—6

Hard Variety

	Large white tears	Small white tears	Large faintly coloured tears	Small faintly coloured tears	More deeply coloured tears	Crude unsorted
Grade according to French System	Gomme Grosse Blanche	Gomme Petite Blanche	Gomme Grosse Blonde	Gomme Petite Blonde	Gomme Deuxième Blonde	
Moisture, per cent. ...	11·90	9·89	11·82	9·91	12·15	11·37
Acidity (milligrammes of KHO required per gramme)	2·78	2·86	2·93	2·67	2·86	2·66
Ash, per cent.	2·77	3·18	3·06	3·24	3·28	2·90
Strength, as measured by viscosity of 10 per cent. solution... ...	111	95	112	98	105	94
Ditto, ditto, 20 per cent. solution	102·5	98·5	111	95	103·5	93·5

KORDOFAN GUM

Softer Variety

	Crude, unpicked	Selected, white tears	Selected, slightly darker tears
Moisture	12·14	11·69	11·95
Acidity (milligrammes KHO required for 1 grm. of gum)...	2·48	2·53	2·57
Ash	2·86	2·80	2·77
Strength, as measured by the viscosity of 20 per cent. mucilage	92	90	87·5
Character of 10 per cent. mucilage	Light yellow. No marked odour nor taste	Pale straw colour. No marked odour nor taste	Straw colour. No marked odour nor taste

SENEGAL GUMS. Picked

	Gomme Grosse Blanche	Gomme Petite Blanche	Gomme Grosse Blonde	Gomme Petite Blonde
Moisture, per cent.	11·20	10·50	10·48	9·18
Acidity (milligrammes of KHO required for 1 gramme of gum)	2·90	3·33	3·21	2·45
Ash, per cent.	2·90	3·33	3·21	2·45
Strength, as measured by the viscosity of solution of 10 per cent.	98	83	90	85
Ditto, ditto, of 20 per cent. ...	104	92·5	99	93·5
Character of 10 per cent. mucilage	Very light straw colour. No marked taste nor odour	Light straw colour. No marked taste nor odour	Dark straw colour. No marked taste nor odour	Dark straw colour. No marked taste nor odour

SENEGAL GUM. CRUDE

	GOMME DU BAS DU FLEUVE			GALAM		SALABREDA
	H. R. & Co. Collected in comparatively moist atmosphere near the sea	H. R. & Co. Collected higher up the river under more normal conditions	Soc. I. et T.	H. R. & Co.	Soc. I. et T.	Soc. I. et T.
Moisture, per cent.	9·60	10·50	10·42	10·19	10·57	11·51
Acidity, expressed as milligrammes KHO required for 1 gramme ...	2·14	2·50	2·27	2·54	2·50	3·56
Ash	3·41	3·36	3·33	3·22	3·39	2·81
Strength, as measured by the viscosity of a solution of 10 per cent. ...	92	96	68	64	63	68
Ditto, ditto, of 20 per cent. ...	83·5	86·5	79	83·2	82	85
Character of 20 per cent. mucilage	Light brown. Slight sourish taste. Large amount of reddish brown sediment	Dark straw colour. Very slightly bitter taste	Darker than the former. Bitter, sourish taste	Sourish, slightly bitter taste. Light coffee colour	Dark yellow. Slight sourish taste	Deep coffee colour. Astringent, sour taste

It would appear that the Kordofan gum is more uniform in composition, and that the Senegal crude gums contain a notable proportion of weaker gums, possibly from varieties other than *A. Senegal*.

Both hard and soft Kordofan gums are obtained from the *A. Verek* (Hashab). The hard variety is collected as noted above from young, and the softer from older trees. At the present time the two are collected together; but abroad they are picked out, the hard variety, it is said, for dyeing and finishing silks and other fabrics, and the softer for confectionery and fine pharmaceutical products, etc.

NOTES ON THE DETERMINATION OF VISCOSITY OF GUM SOLUTIONS

Determination of viscosity

Several samples of Sudan gum tested at the Imperial Institute were subsequently examined in this laboratory. The comparative viscosities obtained were so much at variance that a number of experiments were instituted in order to determine the conditions affecting this determination and the possible sources of error.

The instrument employed at the Imperial Institute might be described as a minute pipette, the bulb of which had a capacity of about one half a c.c., and the outlet being a capillary tube ten centimetres long. The determination was made by filling the bulb with the liquid to be tested and noting the number of seconds required to discharge through the capillary tube. This averaged something like ten seconds.

There are several objections to such a form of instrument, among which may especially be mentioned the want of provision for controlling the temperature, the shortness of the time of observation, and the fact that it will not permit of observation on any but comparatively

weak mucilages. Gum is, for many purposes, used in very strong solution, and it is highly desirable that a form of instrument be adopted which will allow of comparisons at the same concentration. The simple form of instrument described by Ostwald,* which is essentially that in Fig. 97, could be made to answer the purpose if the tube connecting the two bulbs be made of sufficiently large bore. A finely capilliary tube will not allow the stronger solutions to pass. The determination is made by introducing a known quantity of the liquid at C, and sucking up at D until the liquid has risen above the mark at A. The times occupied by the liquid in flowing from A to the lower mark at B is noted. The arrangement has the advantage that the bulbs may be submerged in water in a beaker and the temperature kept at

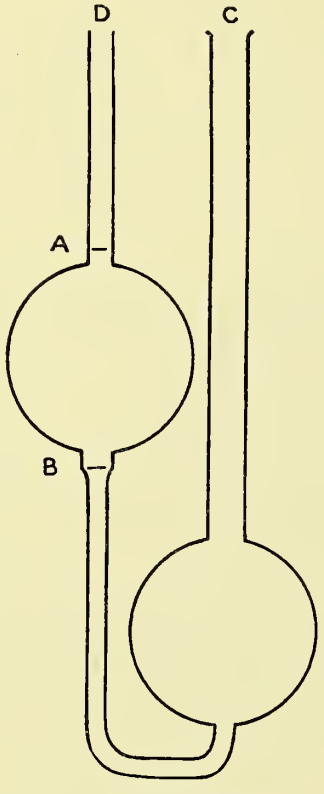

Fig. 97.—Glass Viscosimeter

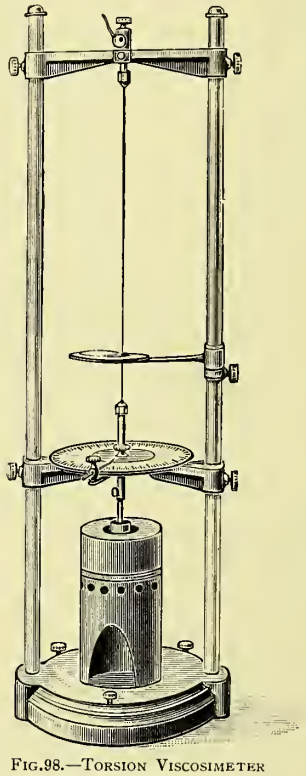

Fig.98.—Torsion Viscosimeter
Devised by O. S. Doolittle, for use in lab. of Philadelphia and Reading Railroad Co.

whatever point desired. Repeated tests can be made without alteration of temperature or fear of entrance of dust—a serious matter when working at some seasons in the Sudan.

The objection to all such forms of instrument is that they are not wholly satisfactory for wide ranges of viscosity. A tube suitable for 30 per cent. gum solutions will be comparatively insensitive when used to compare solutions of only 10 per cent. concentration. If, however, solutions of moderate range of concentration only are to be compared, and the tube is of suitable bore the results are all that could be desired.

Torsion Viscosimeter

The Torsion Viscosimeter of Doolittle designed especially for the determination of the viscosity of oils at varying temperatures, has been applied to gum solutions, with very satisfactory results. One great advantage which the instrument offers is that the indications are not affected by suspended matter unless the amount present is excessive.

* Physico-Chemical Measurements, Ostwald, p. 163.

With it determinations over very wide ranges of viscosity may be made, but for the stronger solutions the method of observation recommended by the makers must be modified or very serious errors may be introduced. The instrument, which deserves to be better known, is shown in Fig. 98.

A steel wire is suspended from a firm support and fastened to a stem which passes through a graduated horizontal disc, thus allowing the torsion to be exactly measured. The disc is adjusted so that the index points to zero, showing that there is no torsion in the wire. A cylinder, 2 inches long by $1\frac{1}{2}$ inches in diameter, having a slender stem by which to suspend it, is then immersed in the oil and fastened by a thumb-screw. The oil is surrounded by a bath of water or paraffin, according to the temperature at which the observation is to be made. This temperature being observed while the disc is resting on its supports, the wire is twisted 360° by means of the knob at the top. The disc being released, the cylinder rotates in the oil by reason of the torsion of the wire. The action is analagous to that of the pendulum. If there were no resistance to be overcome, the disc would revolve to zero, and the momentum thus acquired would carry it again to 360°. In reality, the resistance of the oil to rotation causes the revolution to fall short of 360° in proportion to the viscosity of the liquid. The retardation thus produced is a delicate measure of the viscosity.

There are a number of ways in which this retardation may be read, but the simplest is the number of degrees retardation between the first and second complete arcs covered by the rotating pendulum. For example, suppose the wire to be twisted 360° and the disc released so that rotation begins. In order to obtain an absolute reading which shall be independent of any slight error in adjustment, the start from 360° is ignored, and the first reading taken at the end of the first swing. The next reading, which is on the other side of the 0 point, is also ignored, as it belongs in common to both arcs. The third reading is taken, which will be at the end of the second complete arc and on the same side of the 0 point as the first reading. The difference between these two readings will be the number of degrees retardation caused by the viscosity of the oil.

Methods of reading

Suppose the readings are as follows:—

First reading, right-hand	355·6°
Second „ left-hand—ignore	—
Third „ right-hand	338·2°
	17·4° retardation

In order to secure freedom from error, two tests are made—one by rotating the milled head to the right, and the other to the left. If the instrument is in exact adjustment, these two results will be the same; but if it is slightly out, the mean of the two will be the correct reading.

The above method will answer for comparing solutions not too strong, say up to 15 or 20° retardation. Beyond this a gradually increasing error is introduced which becomes a very serious one when testing solutions of gum of 30 per cent. strength, and especially when the viscosity in weaker solution is compared with that in stronger. It is evident that the extent of retardation will depend upon the point at which the first reading is taken.

In the example given above, the first reading was at 355·6°, at which point the wire was under almost complete torsion. In the case of a very viscous solution this first reading may be only, say, 200°, obviously the wire is under much less torsion at this point, and the subsequent degree of oscillation being less, the retardation observed will be very considerably

less than the true figure. It may happen that a 30 per cent. solution, read in this way, may show little more or even less viscosity than one of 20 per cent., the actual viscosity of which is very much greater.

Obviously in order that a correct observation may be made, the first reading should always be at the same point. In the stronger solutions the number of degrees of retardation is so great that the error introduced by starting from zero, may be ignored. The reading will then be the retardation noticed at the end of one complete swing and the return to the same point, thus :—

	First reading	360 (or zero)
	Second „ (R)	280 (ignored)
	Third „	220
	Retardation	140
And again	First reading	360
	Second „ (L)	281 (ignored)
	Third „	221
	Retardation	139
	Average retardation	139·5°

For dilute solutions, it has been found more satisfactory to allow the disc to swing back and forth a number—say 5 times, and note the total retardation. In the case of 10 per cent. gum solutions the total retardation divided by 4·68 has been found to give a much more reliable figure than that derived from an observation on a single swing.

In order to overcome the variations in different instruments, each one is standardized against pure cane-sugar solutions, and the viscosity is expressed in the number of grams of pure cane-sugar contained in 100 c.c. of the syrup at 60° F., which will give the retardation designated at 80° F. These readings are obtained by making a number of solutions containing known amounts of pure cane-sugar, and determining the retardation of each. A curve is then marked out on a piece of plotting-paper, the number of grams of sugar in 100 c.c. of the different syrups representing the abscissas, and the degrees of retardation the ordinates. This curve enables us to interpolate the value of each degree of retardation in terms of pure cane-sugar, and in this way a table of viscosities is drawn up and furnished with each instrument. This table renders the results obtained by the different instruments strictly comparable.

The above method serves to standardize the instrument, but as the curve of viscosity in the case of sugar is markedly different from that of gum, a second curve has been plotted which enables one to express the viscosities recorded in terms of average gum arabic of good quality (see chart). These figures give a much juster idea of the comparative strength of gums than the figure representing their viscosity. Thus, comparing crude Senegal gum "Gomme du bas du fleuve" with the best grade picked from it, we have the following figures :—

Viscosity and "strength" compared

Crude gum, viscosity in degrees of retardation ...	31
Picked white gum „ „ „ ...	56

From which it would appear that the second gum was twice as strong as the first. Actually, as may be ascertained from the chart, the amount of gum required to produce the above viscosities were

Crude gum	85
Picked	100

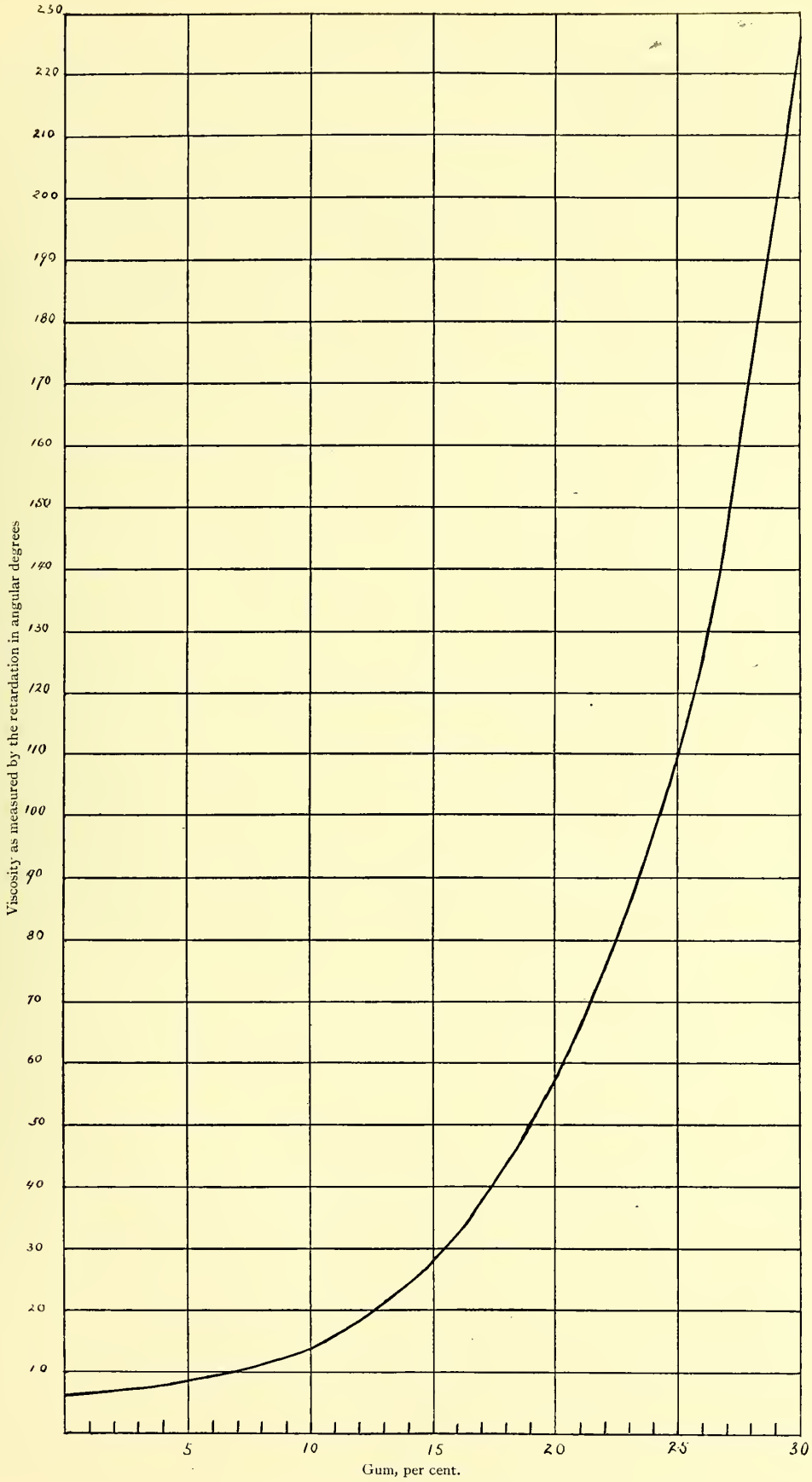

FIG. 99.—CHART OF VISCOSITY OF GUM SOLUTIONS

It is this figure, representing the true strength of the gum, which is recorded in the tables on pages 236 and 237.

Precautions to be observed

PRECAUTIONS TO BE OBSERVED IN DETERMINING THE VISCOSITY OF GUM SOLUTIONS.—The results of numerous experiments have indicated clearly that great care must be exercised to make the determinations under exactly similar conditions, if trustworthy and comparable figures are desired. Slight, apparently unimportant, variations in the method of procedure may be followed by very considerable alterations in the viscosity. For example, a solution was made by adding water to the powdered gum, and allowing to stand, without shaking, over night. The solution was then agitated until apparently homogeneous and filtered twice—once through cotton wool, and again through paper, by the aid of a vacuum pump. The results of successive determinations were as follows, the figures representing the number of seconds required for delivery of the same quantity, through the same aperture at the same temperature :—

First trial . .	250	seconds
Second „	240	„
Third „	234·5	„
Fourth „	232·3	„
Fifth „	230	„
Sixth „	225	„
Seventh „	225	„
Eighth „	225	„

An hour elapsed between the first and the sixth determination, all this time being required, after filtration, before the solution had reached a condition in which it would furnish constant results. The effect was apparently connected with the fact that the gum remained all night at the bottom of the flask, in a state bordering on that of a jelly.

Effect of temperature of solution

Temperature, not only at the time of the observation, but more especially of the liquid at the time solution takes place, has a very marked influence upon the viscosity of the mucilage. A solution made at ordinary temperature (90° F. in this laboratory) will have less viscosity than one made of the same strength in ice cold water, and higher viscosity than a similar one made with hot water, all the solutions being, of course, brought to the standard temperature at the time of testing. In some cases the alteration is slight, but in others it is astonishingly great. The following are instances. The figures represent retardation in angular degrees, in the torsion viscosimeter at 90° F.

VARIETY OF GUM		Solution made at 90° F.	Solution made at 212° F.
Senegal "Bas du fleuve"	30 % solution	96	69
„ „ „	10 % „	13·7	10·7
„ "Grosse blanche"	30 % „	140	46·8
„ „ „	10 % „	14·1	10·2
„ "Petite blanche"	30 % „	82·7	81
„ „ „	10 % „	12·37	11
„ "Grosse blonde"	30 % „	102·3	98·5
„ „ „	10 % „	13·1	11·1
„ "Petite blonde"	30 % „	101·3	95·8
„ „ „	10 % „	12·7	11·7
Kodofan white	30 % „	137·	94·7
„ „	10 % „	15·2	11·2
„ "blonde"	30 % „	138·7	98
„ „	10 % „	14	11·8
„ unpicked	30 % „	125	97
„ „	10 % „	13·85	11·37

If heated after solution had been completely effected the reduction was found to be much less, and in many cases practically nil.

A solution of Kordofan gum made at 90° indicated a viscosity of 10 degrees retardation. The same gum dissolved at 32° and then brought to 90° showed a viscosity of 11.

Effect of dilution

Effect of Dilution.—A solution of given strength made by dissolving the gum in the requisite quantity of water will have a higher viscosity than one made by diluting a stronger solution to the same point. The difference in viscosity is slight in most cases, but in some it is considerable. Thus:—

	Retardation in angular degrees.	
	Solution made direct.	Solution made by dilution.
Bas du fleuve No. 1	29·5	29
„ „ No. 2	33·4	31·5
„ „ No. 3	25	24·2
Galam „ No. 3	28·7	28
„ „ No. 12	27·5	25·2
Salabreda	31	28·5

Finally, the viscosity of gum solutions is very much affected by the temperature at which the observations are taken. The liquid should not vary more than about a quarter of a degree Fahrenheit from the temperature chosen for the comparisons.

Method recommended

Method of preparing Gum Solutions for Viscosity Determinations.—The moisture having been determined by heating the powdered gum to constant weight in an air oven, at 105° to 110° C., an amount is weighed out equivalent to 40 grammes of the dry gum. This is placed in a bottle of 250 c.c. capacity and sufficient water weighed out in a beaker to bring the total weight to 200 grammes. The gum is well mixed with the water by means of a rod provided with a well-projecting rubber tip, until no more particles can be seen. The bottle is then closed by means of a perforated rubber stopper through which the rod passes, and the mucilage allowed to stand for 5 or 6 hours. If a 30 per cent. solution is made the solution should be allowed to stand over night.

The distilled water used for solution should be at about the temperature at which the observation is to be made, and the mucilage should be well mixed again before it is brought to the standard temperature and tested.

Tureba

An earth of this name is very generally used in the Sudan as a remedy for syphilis. The most highly prized is that from the vicinity of Berber; and the wonderful effects ascribed to it are attributed to the presence of mercury. How this idea originated is not known—probably simply by inference from its supposed anti-syphilitic effect. So general is the belief in the presence of mercury that the native hakims even employ small cones for treatment by fumigation.

Absence of mercury from "tureba"

Five different samples of tureba were purchased in the Omdurman market. Although in most cases as much as a pound of the earth was employed in the test, not the faintest trace of mercury could be detected. The same result was had from the examination of one of the fumigation cones mentioned above. Dr. Balfour reports one case in which mercury was found. This sample was obtained from a native hakim and possibly the mercury was added to it.

Figs. 100 & 101.—Ben Naga, Distant and Near Views

The usual method of employment appears to be as follows: A couple of pounds, more or less, of the earth is treated with hot water and, in the morning, the clear dark brown supernatant liquid is poured off and drunk. An examination of the watery extract prepared in this way showed it to contain a considerable proportion of sodium carbonate and bicarbonate along with a certain, usually smaller, amount of sodium sulphate and chloride. A large amount of organic matter—humates, etc.—was present in all the samples, as well as a trace of iodine. The last was however in far too small proportion to have any medicinal effect.

The exhibition of such a quantity of fairly strong saline solution was naturally followed by purgation. The average native does not require more than this to convince him of the potency of his medicine.

A Novel Use of Asbestos

Asbestos shrouds

A material, taken at first to be feathers, found surrounding the bones of a human being in an ancient grave at Naga, proved on examination to be finely fibrous asbestos. The asbestos was of yellowish colour, due to the presence of a small amount of organic matter, but on heating in the flame it became a pure white. The loss on heating—water and the trace of organic matter—was 14·9 per cent. Mr. Crowfoot, Assistant Director of Education, by whom the discovery was made, kindly furnishes the following particulars:—

"When I had the honour of accompanying the Governor-General to Naga last spring, we saw, like Lepsius, signs of an old burial place on the rising ground to the north-east. The graves are marked by flat burnt bricks arranged, some in rough circles, some in more or less regular rectangles. On a second visit, therefore, last autumn, in the company of Mr. Sterry, to inspect the progress of the well, I determined to utilize the services of one of the well-sinkers in investigating the spot.

"We selected one of the most regular of the oblong graves and removed the bricks which had been simply laid in a single course upon the surface of the ground. As we dug down the earth proved to be loose and soft, obviously the filling of a narrow shaft, the sides of which were firm. At a depth of 4 feet we came upon fragments of bone and a substance which looked like mouldering feathers. Continuing, we found that these belonged to a skeleton lying from north to south, with the head to the south, and originally wrapped completely in the same feathery substance, which Dr. Beam has shown to be asbestos. Of funeral offerings, of beads or jewels, there was no trace, and the bones were too much broken to enable us to say exactly how the body lay, that is, whether it had the eastward tilt which is characteristic of Muslim burials. None of the men with us, two Arabs and a Sudanese, recognized the grave as Mohammedan and there is no tradition about the place among the people.

"As to the period to which the burial belongs our only clues at present are the following:—

"Naga was still a flourishing town in the third and fourth centuries, A.D.; this is proved by the style of temples remaining. The bricks set round the grave undoubtedly came from some building connected with this town. The burial, therefore, cannot be more than 1,500 years old, but whether it belongs to the Christian period (up to, say, 1,500 A.D.), or to the Muslim period (after 1,500 A.D.) we cannot say.

"The single line of bricks which marked the grave has not been covered; from this one might argue that the burial was very recent, but the accumulation even on the lower parts

of the site, has been very small—about a foot in a thousand years—and this is on high ground, which is more likely to have become denuded than covered.

" The use of asbestos as a funeral shroud is, so far as I know, unparalleled ; it suggests that the deceased looked forward to some fiery ordeal, but these grim expectations are common to both Christians and Muslims.

" The absence of traditions about the place shows that it is not quite recent, but we know so little about the history of the Sudan that one cannot say at what period the people who lived here were so advanced as to have learnt the properties of asbestos, and how to weave it into a winding-sheet.

" Further excavation will certainly tell us whether this cemetery is Muslim or not."

Ancient Gilded Pottery

" Gilding " of ancient pottery

Two fragments of ancient pottery covered with a dull golden coloured substance were submitted for examination by Mr. Crowfoot. The gilding was found to consist of a rather fine scaly powder of golden-coloured mica. So far as I am aware this is the only instance of mica having been employed for such purpose. The following notes have been furnished by Mr. Crowfoot :—

" Both these fragments of pottery came from the Halfa province.

Mica as gilding material

" One was found inside the small temple on Gezirat Al Malik, an island near Senna. This temple was probably begun under the middle Empire, as a stele of Usertses III. was found against it, but the decoration, and at least one figure found inside it, belonged to the 18th Dynasty. The vase from which this fragment comes was a long-necked wheel-made vase of red well-levigated clay, and was painted with the gold coloured dust inside and outside.

" The second fragment was picked up inside the walls of the old fort at Shelfak, between Senna and Sarras ; it is of rather coarser clay than the first. Nothing is known as to the date of this fort, but it probably belongs to old Egyptian days."

Gunpowder made by the Khalifa

Khalifa's gunpowder

The following results were obtained from the examination of a sample of gunpowder made in the time of the Khalifa. The sample was obtained from the Department of Works, the powder now being used for blasting.

Charcoal	13·9	per cent.
Sulphur	10·5	,,
Nitre	75·6	,,
Total	100·0	,,

The nitre is of very fair quality, containing very little impurity. The powder is well mixed, but the grains are rather irregular in size.

The above figures are well within the limits of ordinary gunpowder, which is usually a mixture of 75 parts of nitre with 12½ to 15 parts of charcoal and 10 to 12½ parts of sulphur.

Benga.—A Magic Powder from the Bahr-El-Ghazal

"Benga" a divination powder

We are indebted to Major Bray for an interesting sample of "benga," a powder used in the Bahr-El-Ghazal district for divinations. Major Bray writes as follows: "It is said to be very valuable, and to be obtained from somewhere south of Yambios. Only big 'Sultans' can use it properly. I understand that a chicken or fowl is selected, given some of the powder and tied up near a fire. If the chicken dies the omen is bad, and the war (or whatever the omen concerned) is not made; but some of the feathers of the dead chicken are tied up on a stick, or on a sort of candlestick made of wood, split and forked, about 4 feet high, and put in the road or outside a tukhl. Many of the tukhls have the sticks, apparently permanently fixed, outside them. Sometimes there is a little clay pot inside the forks in which there are chicken bones. The powder is said to be deadly poison."

On examination, the powder was found to consist of a brownish-red oxide of iron, with a small amount of fine sand. It contains no organic matter and no trace of arsenic, mercury or other metallic poison. In all probability the powder was selected because of its bright colour, and when a bad omen was desired poison of some sort was added to it.

Iron Ore from the Bahr-El-Ghazal

Iron ore, Bahr-El-Ghazal

In the Bahr-El-Ghazal district the natives reduce their own iron from ore which is found plentifully in that locality. The reduction is effected in small furnaces by means of charcoal. A sample of the ore brought from Wau by Col. Penton, the former P.M.O., had the following composition:—

Moisture and small amount of organic matter	15·42 per cent.
Sand, etc., insol. in acid	28·24 „ „
Ferric oxide	53·20 „ „
Equiv. to metallic iron	37·24 „ „

The iron reduced from this ore is said to be of excellent quality.

Nyam Nyam Arrow Poison

Nyam Nyam arrow poison

The coating of arrows with poison is common among the Nyam Nyams. A fairly large quantity scraped from some arrows furnished by Captain Bethell was dissolved in water and injected by Dr. Balfour into a rabbit, but without effect of any kind. However poisonous the material had been originally, it had evidently become inert by age. Later it was learned that the natives recognize this fact and re-coat their arrows before each engagement.

The substance scraped from the arrows was to a large extent soluble in water. Some resin-like residue was left which gave reactions recalling those of euphorbia resin, with which, however, it did not appear to be identical. Euphorbia is much used in some parts of Africa as an arrow poison.

As the poison originally present had become inert, it was not thought advisable to carry the investigation further on this sample.

Laboratory Notes

A New and More Accurate Form of Hydrometer

New form of Hydrometer

In measuring the specific gravity of a liquid by means of the ordinary form of hydrometer it is difficult to make a rigidly accurate reading. The point which should be read is that at which the surface of the liquid intersects the stem of the hydrometer. In the case of opaque or semi-opaque liquids, *e.g.*, milk, this point is not visible, as the liquid is drawn up the stem by capillary attraction. Even in the case of transparent liquids, the

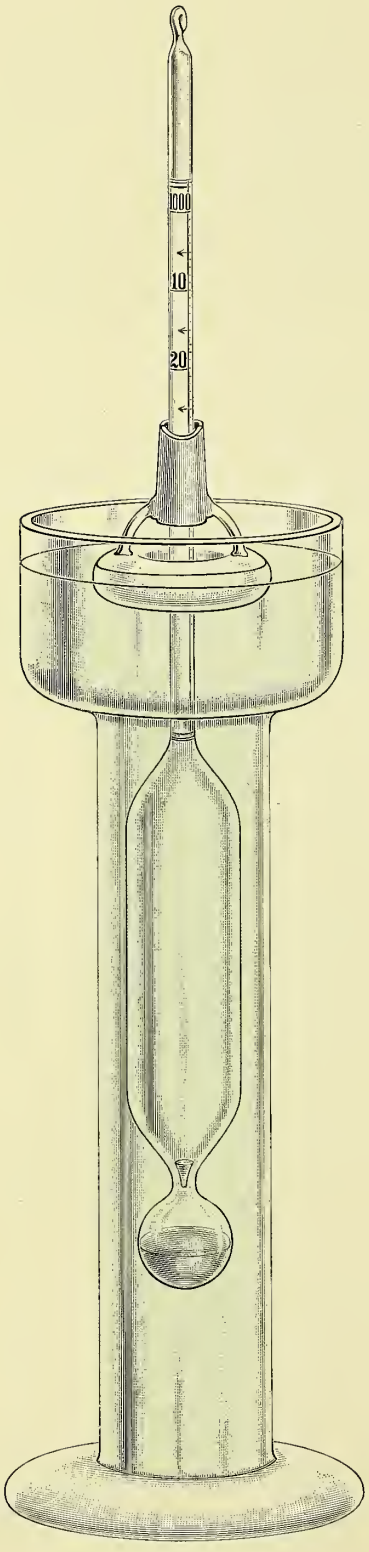

Fig. 102.—Complete Instrument in use

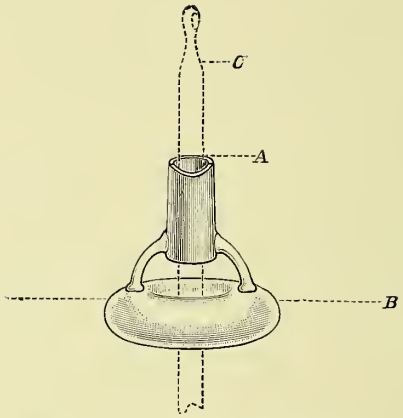

Fig. 103.—Floating Index showing Method of Reading

A Point at which reading is taken
B Level of liquid
C Stem of hydrometer

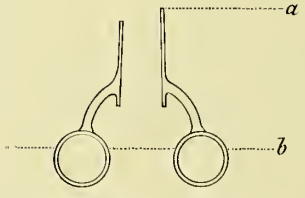

Fig. 104.—Cross Section of Floating Index

a Point at which reading is taken
b Level of liquid

presence of the meniscus just mentioned introduces a difficulty. In order to obviate this, the arrangement shown in Fig. 102 has been devised, and has been found to answer the purpose admirably. It consists of an ordinary form of hydrometer provided with a float which is used in the graduation of the instrument. The reading is made, not at the surface of the liquid, but at the point where the top of this float cuts the stem of the hydrometer. See Figs. 103 and 104.

The float consists of a hollow ring of glass supporting an upright short section of amber-coloured glass tubing, cut off at a slight angle, the uppermost portion of the tube being used as the index. (An alternative arrangement is a short section of colourless glass tubing with a straight line etched on its surface.) In this way, error arising from the presence of the meniscus is avoided, and fractional parts of a degree may be read with the greatest ease.

The float has a fragile appearance, but the one made for us by C. Kob and Co. has been in use over a year and remains unbroken. It could doubtless be made of thin metal, gold plated, if desired.

When only small quantities of liquid are available the form of jar shown in Fig. 102 may be adopted with advantage. The upper portion is flared in order to receive the float but the lower portion of the jar is only slightly larger than the bulb of the hydrometer.

In use it is essential that the stem remain dry in order that it may not stick to the upright tube of the float. Wetting of the stem may be avoided by proceeding as follows:— The stem of the hydrometer being dry the float is passed over it and allowed to rest on the bulb. The hydrometer is then lifted by the point of the stem and gradually let into the liquid. If there is any doubt as to the instrument having found its proper level, the base of the hydrometer jar may be held firmly to the table by one hand and the jar gently tapped with the other.

When removing the hydrometer the float should be taken out first, in order to keep the tube dry and ready for a second test if required.

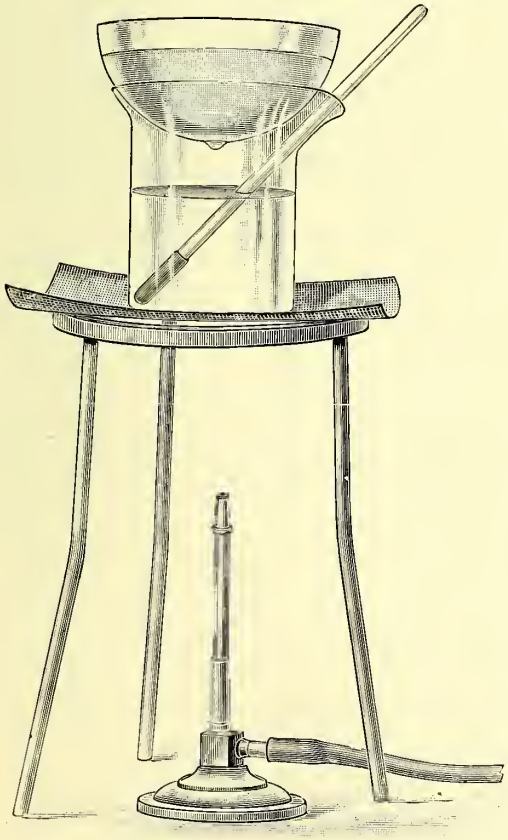

Fig. 105.—A Simple Arrangement for Determination of "Crude Fibre"

Determination of "Crude Fibre."

Determination of Crude Fibre

The method of determining crude fibre most generally in use consists in boiling the fat-freed material for half an hour with 1·25 per cent. sulphuric acid and 1·25 per cent. sodium hydroxide solution successively. The boiling is effected in a flask provided with an inverted condenser, in order to avoid concentration of the liquid. The method is usually very troublesome, as the liquid foams and the solid is carried up into the condenser tube from which it is dislodged only with difficulty.

The simple arrangement exhibited in Fig. 105 is free from the above defect, and the manipulation generally is much easier. The

boiling takes place in a beaker on which rests a semi-spherical glass evaporating dish nearly filled with cold water. Very little steam escapes uncondensed. If the material to be analysed is carried up the side of the beaker it is readily dislodged and brought back into the liquid by means of the rubber-tipped rod.

A Simple Form of Blast Lamp for Use with Benzine

Benzine Blast Lamp

As already noted, the acetylene gas employed in these laboratories has been found very destructive of platinum ware. After several unsuccessful attempts to effect fusions of silicates, etc., by means of spirit bunsens and alcohol blast lamps, the arrangement shown in Fig. 106 was finally adopted. The blast from a Fletcher blower is divided into two by means of a Y tube. One of these is connected directly with the air inlet of an ordinary blast lamp,

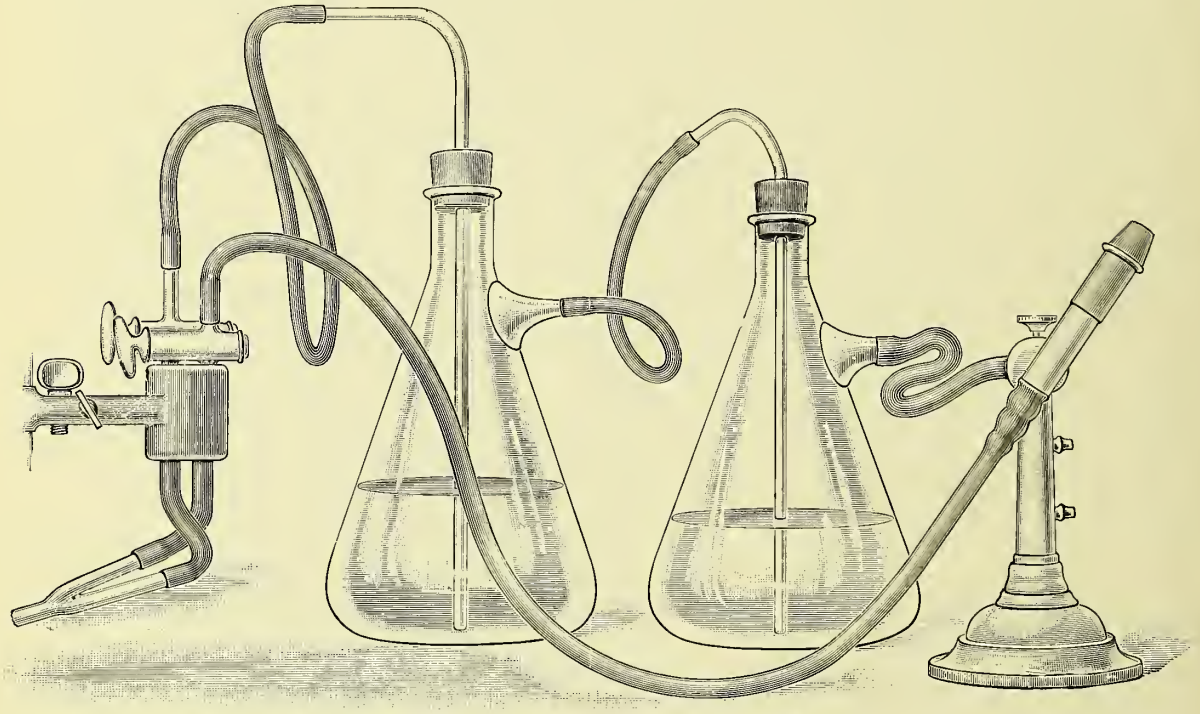

Fig. 106.—A simple form of Blast Lamp for use with Benzine.

and the other made first to pass through one or two bottles containing benzine. Each of these blasts is controlled by means of a stopcock. The air jet of the lamp should be the largest of the three usually supplied.

With a little practice in adjusting the air supply, fusions may be made without difficulty. The flame is found to have no harmful effect on platinum.

Conclusion

In conclusion I wish to acknowledge the very great part which Mr. Goodson has taken in the work which has been done since the beginning of the year. In addition to the Nile water examinations, which will be published in the next report, he has lent a very helping hand in practically all the analyses and investigations which have been made since his arrival.

LIST OF ILLUSTRATIONS

INDEX